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# THE CONTROL OF CRYSTALLINE GLAZES*

By F. H. Norton

Abstract

In this investigation there is carried out the carefully controlled heat treatment of a single crystalline glaze in which both the crystallizing and growth velocity were determined for the four types of crystal produced. It was found possible to produce crystals at any desired location by seeding; their size could be controlled by the growing time and their shape by the growing temperature. Commercial production of crystalline glazes is possible if close temperature control is maintained.

## I. Crystalline Glazes

This type of glaze is one which upon cooling readily forms comparatively large crystals. The base is a silicate glass, and oxides, such as ZnO or $TiO_2$, are added as crystallizers. Many other oxides, however, will serve, as an examination of the literature will show. Often a coloring oxide is added in small amounts to be differentially absorbed by the crystal and base glass, thus building up color contrasts.

It should be noted that the only crystals large enough to be of direct value in a glaze of this kind are those which can grow mainly in one plane, for the thickness of the glaze layer limits the size of an isometric crystal to a maximum diameter of about 0.5 millimeter. An examination of the crystal systems will show that cubic crystals, for example, can not form in large sizes under these conditions. The hexagonal system seems to be best suited to produce crystals in a plane as, for example, frost on a window.

There is a considerable amount of literature pertaining to crystalline glazes, but it will be found to deal almost entirely with the composition of the glaze. In fact, scarcely a case came to light where the temperature schedule was given throughout the firing with the needed precision. Inasmuch as this paper deals mainly with the heat treatment of the glaze, this literature will not be reviewed.

## II. Theory of Crystal Development from Glasses

It will perhaps be well first to review the present understanding of the glassy state. One of the simplest glasses, vitreous silica, was studied by Warren,[1] who came to the conclusion that the X-ray diagram produced need not be explained by the presence of crystallites, as was previously believed, but could be satisfied by a random network of silicon-oxygen tetrahedrons with a fairly uniform spacing. The binary glasses are more complicated; the soda-silica series, however, has been worked out by Warren and Loring[2] and the lead-silica series by Bair.[3] In both cases, the structure seems to be formed of the same random network of silicon-oxygen tetrahedrons with the cations held in the meshes. This random arrangement is the reason why a continuous series of glasses can be formed with no detectable discontinuities in the properties.

Before this clear picture of the glass structure was presented, Zachariasen[4] advanced the interesting theory that the only glass-forming substances are those in which a small energy difference exists between the fused and crystal state. On this basis he listed the crystal structures that should form glasses, and in practically every case glasses have been made from them. The most important, of course, is silica which is the only one of direct interest here.

Coming next to the formation of crystals from a glass, it is necessary to consider the difference between this action and the formation of crystals from a melt at the liquidus temperature. In the latter case, the process takes place at a constant temperature, and the relatively free and mobile atoms or atomic groups can easily attach themselves onto the growing crystal lattice in a regular manner. In the former case, the process is not as simple because there is a considerable temperature range in which the crystals form, and as the glass is comparatively viscous the atomic groups

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, March 23, 1937 (White Wares Division). Received November 26, 1936.

[1] B. E. Warren, "X-ray Diffraction of Vitreous Silica," *Z. Krist.*, **86** [5–6] 349–58 (1933); *Ceram. Abs.*, **14** [4] 91 (1935).

[2] B. E. Warren and A. D. Loring, "X-ray Diffraction Study of the Structure of Soda-Silica Glass," *Jour. Amer. Ceram. Soc.*, **18** [9] 269–76 (1935).

[3] G. J. Bair, "Constitution of Lead-Oxide Silica Glasses: I–II," *ibid.*, **19** [12] 339–58 (1936).

[4] W. H. Zachariasen, "Atomic Arrangement in Glass," *Jour. Amer. Chem. Soc.*, **54** [10] 3841–51 (1932); *Ceram. Abs.*, **12** [4] 145 (1933).

can not orient themselves so easily. The extensive work of Tammann[5] has shed a great deal of light on this process, and even though much of his research deals with organic glasses, the principles apply equally to silicates. He shows that crystallization occurs in two steps: the first is the formation of nuclei, that is, properly arranged atoms to form at least one unit cell, and second, the growth of these nuclei by the addition of added atomic groups. He defines two cases: one in which the nuclei form and grow in the same temperature range, and the other, in which the nuclei form at one temperature, but grow at a higher one. Blau[6] has shown how these principles can be applied to controlled production of crystals in opal glass.

How does this picture of crystallization harmonize with that of the random network structure? On slowly cooling a glass, the thermal agitation decreases and the bonds become stronger. It may be supposed that when some temperature is reached the bonds representing the crystal structure in certain localized areas form at least one unit cell. At some lower temperature, the random structure becomes so rigid that this shift can not take place. Possibly this temperature is the same as that of the transformation point of the glass. According to Bair, the network is dynamic rather than static, that is, the bonds are continually being broken by thermal agitation of the electrons and continuously re-formed by the attractive forces, or at any one temperature the number of bonds broken per second is equal to those formed per second. As the temperature decreases, the rate decreases until it reaches zero at some temperature. This temperature in an unstressed structure is believed to be the transformation point.

The formation of nuclei would be expected to follow the laws of chance in that occasionally the re-forming bonds will produce a perfect unit cell. The rate at which these happenings occur will depend on the temperature. If it is too high, thermal agitation breaks down the unit cell if it is formed, and if too low, the bonds are too rigid to permit rearrangement. In between, there is a temperature causing a maximum rate of nuclei formation. The number formed would be proportional to the time as determined experimentally by Tammann.

The growth of the nuclei will depend on two factors: first, a breaking of the bonds to allow attachment of the proper atoms, and second, a transfer of unwanted atoms away from the crystal face. If the composition of the glass is the same as the crystal, the second effect would not take place, and we would expect growth to take place at the nuclei formation temperature. On the other hand, if the crystal is quite different from the glass, then we would expect a high temperature to be needed to give sufficient mobility to the atoms, and the growth temperature would be higher than the nuclei formation temperature. This, however, does not quite fit in with the facts, as some of the pure organic glasses of Tammann showed separate crystallization and growing ranges.

## III. The Glaze Used in This Investigation

The single glaze used was one recently developed by R. O. Lane in this laboratory for use on porcelain. While others, equally good, might have been selected, this one produced such excellent results that it was thought to be quite suitable.

The complete glaze is as follows:

$$\left.\begin{matrix} 0.235\ K_2O \\ .088\ CaO \\ .0513Na_2O \\ .0513BaO \\ .575\ ZnO \end{matrix}\right\} 0.162\ Al_2O_3 \left\{\begin{matrix} 1.700\ SiO_2 \\ 0.202\ TiO_2 \end{matrix}\right.$$

0.25% CoO is added to the frit.

All of the composition is fritted except 0.162 $Al_2O_3$ (as kaolin); 0.088 CaO (as $CaCO_3$); and 0.170 $SiO_2$.

It should be kept in mind that the finished glaze may depart widely from this composition, owing to the solution of silica from the tile and to volatilization. The composition also varies with fritting conditions.

The base tile were made from an electrical porcelain body by the usual dust-press method. They were biscuited at 1100°C, which left them quite porous for the application of the glaze by dipping.

## IV. The Kiln and Pyrometer

The tile were fired in a vertical position in a small electric Globar kiln controlled by an induction regulator.

So many inquiries have been received in the

[5] G. Tammann, The Glassy State (Der Glaszustand). Leopold Voss, publisher, Leipzig (1933), 123 pp.; *Ceram. Abs.*, **12** [12] 418–19 (1933).

[6] H. H. Blau, "Crystallization in Glass," *Glass Ind.*, **12** [5] 110–11 (1931); *Ceram. Abs.*, **10** [7] 485 (1931).

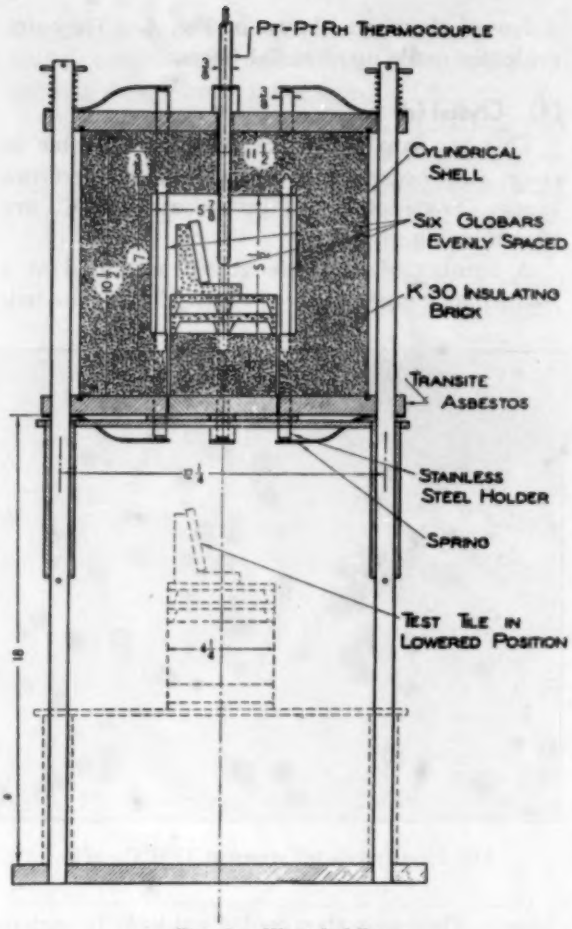


FIG. 1.—Electric kiln.

last few years about this kiln that a scale drawing is shown in Fig. 1. The exact control of temperatures and the ability to drop the specimens for examination during the firing makes this kiln ideal for glaze studies.

The temperature was measured by a platinum thermocouple with the junction about 1 centimeter from the center of the tile face. This couple was calibrated several times during these tests by comparing with a standard couple, which in turn was checked at the freezing point of zinc, aluminum, and copper.* The readings can be depended on to ±2°C. Such precision might seem unnecessary from the point of view of the potter but, as will be shown, 5°C makes a real change in the appearance of the glaze.

## V. Experimental Procedure

The sample tile was placed in the furnace in a vertical position and then carried through the desired schedule. While there were some deviations from the desired values in heating and cooling rates, the constant temperatures were held to an average of ±2°F.

The number of crystals on a tile were measured under the microscope using the appropriate objective. Usually ten regularly spaced stations were measured and an average taken, which was then reduced to the number of crystals per square centimeter.

The size of the crystals was measured in the same way, using a graduated ocular. In the case of the large crystals, the measurements of diameter were made with a milliammeter scale.

## VI. Results of Crystal Development

There were four distinct types of crystal produced in this glaze which may be described as follows:

### (1) Crystal (a)

This is the most prominent crystal in glazes of this type because of its rapid growth, brilliant color, and variety of forms. Some writers have referred to it as willemite ($2ZnO \cdot SiO_2$), but this identification is by no means certain. This crystal sometimes starts as a dark blue, hexagonal branching type, but soon grows as the radial light blue type (Fig. 2). The radial type consists of fine rods embedded in glass extending in all directions from the center to form, if unimpeded, a sphere. In the glaze layer, the growth in one direction is restricted to the thickness of

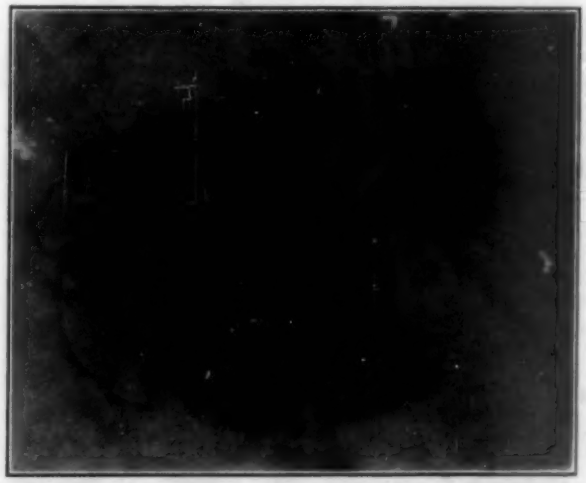

FIG. 2.—Crystal (*a*) showing a dark blue hexagonal center with the light blue form growing out of it; 17×.

* All pure metals were obtained from the National Bureau of Standards.

FIG. 3.—Crystal (*b*) grown at 973°C; 17×.

the glaze, so that a disk-shaped crystal results. Often the crystal starts out radially without the fern-like center and may present various forms in addition to the disk, as will be discussed later.

### (2) Crystal (b)

This is a fern-like crystal of hexagonal habit, and golden-yellow color. The size seldom exceeds 0.4 millimeter in diameter in a one-hour growing period. A number of these crystals which have been grown at 973°C are shown in Fig. 3. This crystal also shows a considerable variation in form.

### (3) Crystal (c)

This is a disk-like, dark green crystal of fairly rapid growth, occurring only at low temperatures.

FIG. 4.—Crystal (*c*) grown at 861°C; 17×.

A few of them are shown in Fig. 4. They are evidently made up of radial fibers.

### (4) Crystal (d)

This is a small disk-like crystal, dark blue in color, that occurs in a very narrow temperature range. Some of these, grown at 1100°C, are shown in Fig. 5.

A number of tile were glazed and fired at a maturing temperature of 1273°C for one-half

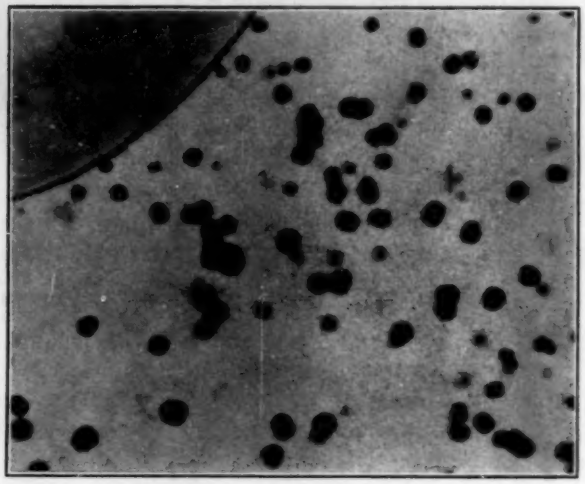

FIG. 5.—Crystals (*d*) grown at 1100°C; 17×.

hour. They were then cooled suddenly to various growing temperatures and held for one hour as shown in *A* of Fig. 6 for a typical case. For each growing temperature, the number and maximum size of each type of crystal was measured, giving the curves shown in Fig. 7. In the case of crystals (*b*), (*c*), and (*d*), the temperature of nuclei formation and growth overlap so that the crystals should vary in size from the smallest to a maximum, as nuclei are forming continuously during the growth period. Crystal (*b*), however, seems to show a predominance of the maximum-sized crystals, which may indicate restriction of growth due to glaze thickness in some cases.

On the other hand, crystal (*a*) has separate growth and nuclei formation ranges so that the crystals can be controlled. The nuclei form so rapidly, however, that it is impossible to complete the lower end of the curve without quenching of greater severity than the tile can withstand. It is also impossible to heat the tile rapidly enough through this range to prevent the formation of many nuclei which give, on growth, a mat glaze.

The only way to produce a limited number of (*a*) nuclei, therefore, is to heat the glaze above the growing range until all but a few are dispersed by thermal agitation, and then, by dropping to the growing range, large crystals will be produced.

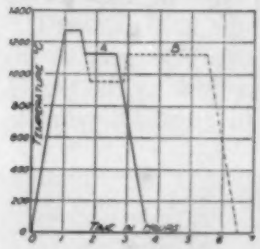

FIG. 6.—Temperature schedules.

By heating a series of tile to different maximum temperatures and then dropping them to the growing range (1140°C), the number of nuclei can be measured. The relation is shown in Fig. 8, where the logarithm of the number of crystals plotted against the reciprocal of the absolute temperature produces a straight line or,

$$\text{Log}\,\frac{n_2}{n_1} = A\left(\frac{1}{T_1}-\frac{1}{T_2}\right)$$

Where $n_1$ and $n_2$ = number of nuclei remaining at absolute temperatures, $T_1$ and $T_2$.

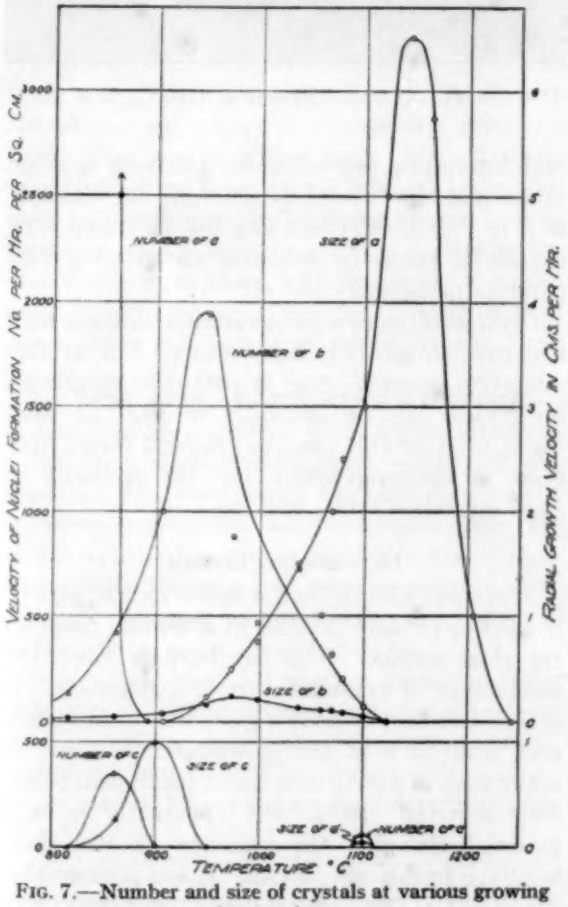


FIG. 7.—Number and size of crystals at various growing temperatures.

This is the familiar Arrhenius equation for the change-of-reaction rate with temperature.

It was thought at first that the nuclei might be due to undissolved mill addition, but a glaze with 100% frit showed the same effect at a slightly lower temperature. The reason why crystalline glazes must be fluid is now clear for a large part of the nuclei must be dissolved at the maturing temperature and this requires fluidity. Most writers on crystalline glazes have commented on the fact that the glaze runs on vertical surfaces, but no satisfactory explanation has been given for it.

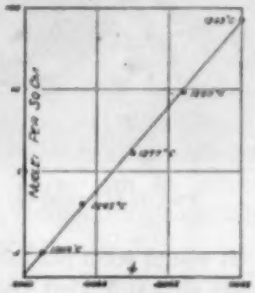

FIG. 8.—Nuclei solution, crystal (*a*).

It was noted that all of the (*a*) crystals were not of the same size, contrary to what would be expected from the nuclei-formation curve. This can be explained either by the fact that the rate of growth is not constant or that a very few nuclei are formed at the higher temperature. It is planned to investigate this matter further, but there is fairly good evidence that the rate of growth is less in the thinner portions of the glaze.

It is of interest to speculate on the reason for several types of crystals separating out of one glass at different temperature levels. The most reasonable explanation would seem to be that, on cooling, the crystal first coming out has an energy level considerably lower than that of the glassy phase and that as the crystals form at lower and lower temperatures their energy level must approach that of the glass. If the identity of these four crystals were known, this hypothesis could be verified.

## VII. Irreversibility of Growth

After a crystal of type (*a*) is grown to a certain size and then cooled to room temperature, upon reheating it has been found impossible under any condition to continue the growth of the crystal. When about 1185°C is reached, the crystal gradually dissolves, leaving a faint pseudomorph of the original, and myriads of new fine crystals fill the glaze from the nuclei formed on cooling and heating. On the other hand, crystals cooled down to 950°C can be [illegible]ain at higher temperatures.

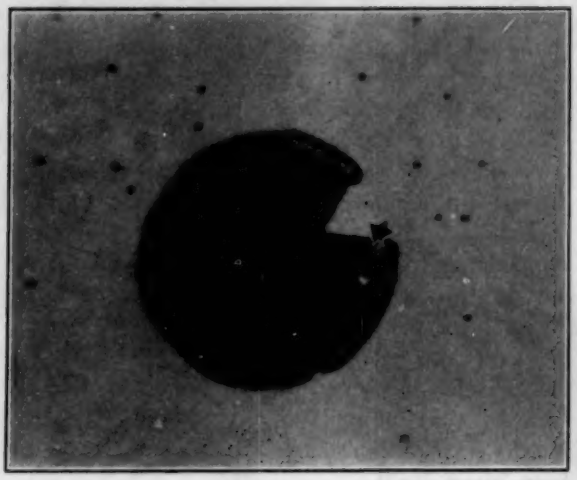

FIG. 9.—Crystal (*a*) grown at 994°C; 17×.

It would seem plausible from this picture of the glass structure that the transformation temperature is the lower limit for regrowth. If the crystal falls below this temperature, it is surrounded by a rigid network of atoms where no thermal breaking of bonds occur. On raising the temperature, thermal agitation would seem to disrupt the crystal, as well as the glass, owing to the nearly equal energy contents of the two. We do not know how general this irreversibility is, but further research along this line should aid considerably in studies on the constitution of glass.

## VIII. Change in Crystal Form with Growing Temperature

Crystal (*a*) varies in shape and color as the growing temperature is increased. We must deal in averages, of course, because there is some variation in the crystal shapes grown at any one temperature. The series of photomicrographs in Figs. 9 to 12 show this variation in shape as the growing temperature rises from 994° to 1206°C.

The color also varies from a pale green at the lower temperature to a deep blue at the higher. This fact can be utilized to grow, for example, very interesting flower-like crystals with a green center and blue border by following the schedule in *B* of Fig. 6. Crystals can also be grown with concentric bands by dropping the growing temperature periodically.

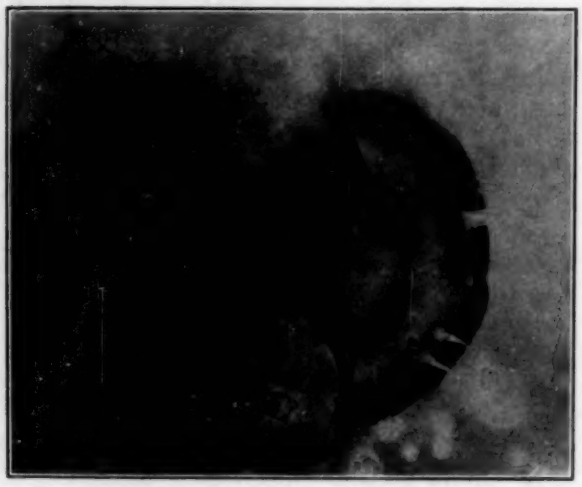

FIG. 10.—Crystal (*a*) grown at 1100°C; 17×.

FIG. 11.—Crystal (*a*) grown at 1164°C; 17×.

Crystals (*b*) show a great variation in shape with a change in growing temperature; but as this alteration is not so clear in photomicrographs as for crystal (*a*), the drawings in Fig. 13 were made to show this change. Several forms may occur at one temperature, and the similarity to snow crystals is rather striking.

## IX. Seeding Crystals

There has always been a desire on the part of potters to produce crystals at a definite place on the glaze surface. This can be done when the mechanism of crystallization is understood. It is first necessary to have a glaze free from nuclei, and, while it is at the growing temperature, to apply nuclei-forming material at the desired point. This material can consist apparently of any material changing the viscosity of the glaze locally. In this case, crystal (*a*) was produced by $Na_2CO_3$, $CaCO_3$, and ZnO, and crystal (*b*) was

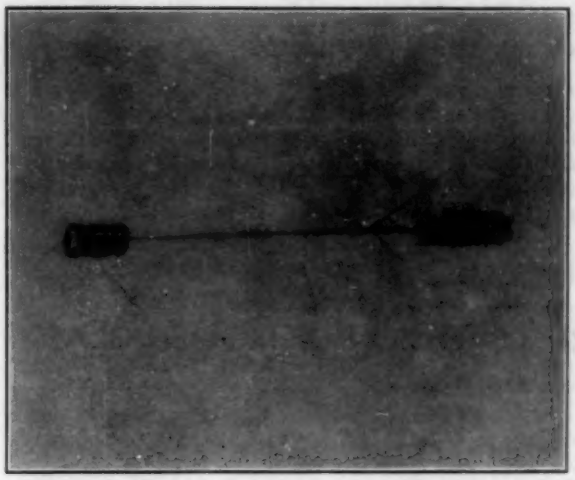

FIG. 12.—Crystal (*a*) grown at 1206°C; 17×.

formed by $SiO_2$. The particles can be applied by blowing a few of them into the hot glaze through a tube or by attaching a particle to a steel point and applying to the glaze. It is possible that particles which do not go into solution in the glaze may form crystallizing centers.

Many crystals were produced by both methods fairly consistently, but it was found difficult with the set-up used to provide a nuclei-free glaze as a base. This may have been due to dust in the kiln or particles freed from the tile base. There seems to be no reason why tile, for example, could not be produced with a three-inch round crystal in the center of each, or vases, with the crystal arranged in a definite pattern. Further investigation of this problem is being carried out at present.

## X. Influence of the Body on the Development

The solution of the base tile in a glaze alters the composition of the original glaze, oftentimes profoundly. Much theorizing has been done on the erroneous assumption that the finished glaze was of the same composition as the unfired batch. Shaw[7] noted that in a lead glaze the silica content increased between 90 and 252% on firing for a comparatively short time at 1000°C.

It is well known that a given glaze will often yield a different result when used on one body or another, which is due to the difference in absorption of the materials of the body into the glaze. In the case of this crystalline glaze, changing from the regular porcelain body to one containing 98% silica altered the character of the (*a*) crystals quite materially.

## XI. Conclusions

It is realized that this study is not by any means complete, but it is hoped that the fundamentals are brought out so that further work can be carried out in a logical manner. While it is dangerous to draw very general conclusions from the results on one glaze, the following are offered with this limitation.

(1) The formation of crystals in the glaze proceeds in the same manner as for crystallization from any glass: first, a formation of nuclei and then a crystal growth. There can be either separate or simultaneous temperature intervals for nuclei formation and growth.

(2) Large crystals in a glaze can not belong to the isometric system. The hexagonal system seems to be best adapted to produce large crystals.

(3) The common type (*a*) crystals, which occur in most crystalline glazes, form nuclei so rapidly on heating up that a high maturing temperature with consequent fluidity is needed to dissolve all but a few of them. They can then be permitted to grow at a lower temperature.

(4) By proper temperature control, a single crystalline glaze can produce an almost infinite variety of effects.

(5) The conditions for crystal growth appear to be irreversible; that is, a crystal once cooled below a certain temperature can never be increased in size by raising the temperature.

(6) Crystals can be produced in any desired place by applying seeds to the glaze at the growing temperature. The use of various seeding materials will allow the growth of more than one type of crystal at the same time. The seeds need

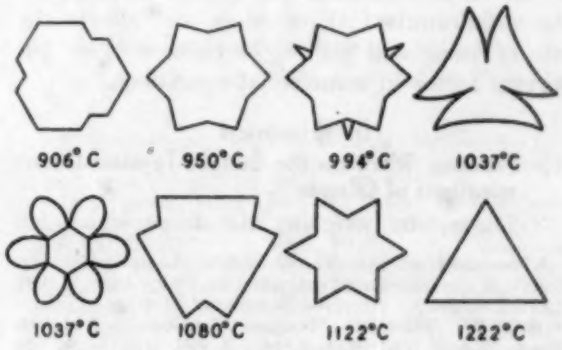


FIG. 13.

[7] D. T. H. Shaw, "Color Formation in Plumbic Glazes," Doctor's Thesis, Mass. Inst. of Tech. (1931); a portion of this thesis was published in *Jour. Amer. Ceram. Soc.*, **15** [1] 37–58 (1932).

not be fragments of the same crystal that it is desired to grow.

(7) The composition of the body has quite a marked influence on the appearance of the crystal glaze due to solution of the body constituents in the fluid glaze.

(8) With a knowledge of the mechanism of crystal formation and growth and an accurate temperature control, there is no reason why commercial production of crystalline glazes can not be carried out.

**Acknowledgments**

The author wishes to acknowledge the work done in this laboratory by R. O. Lane in developing several base glazes for crystallization, one of which was used in this investigation, and to thank S. F. Brown who made many of the furnace runs and crystal measurements.

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# THE EFFECT OF ALUMINA ON THE SURFACE TENSION OF MOLTEN GLASS*

By C. W. Parmelee and C. G. Harman

Abstract

The maximum bubble-pressure method has been used to determine the surface tensions of molten glasses. The compositions of the glasses were those typical of certain types of commercial products. A brief summary of the theory and application of the method is presented. The surface tensions of the glasses studied were of the order of 300 dynes per centimeter and the temperature coefficients were − 0.017 dyne per centimeter per degree centigrade. It was found that $Al_2O_3$ raised the surface tension of soda-lime-silica glass, the increase being almost linear between 2% $Al_2O_3$ and 8% $Al_2O_3$.

## I. Introduction

### (1) Purpose of the Investigation

The primary purpose of this work was to study the effect of alumina on the surface tension of soda-lime-silica glasses. A second purpose was to make a further study of the technique involved in the measurement of the surface tensions of glasses by the maximum bubble-pressure method.

### (2) The Value of Surface-Tension Data

Surface-tension data may be helpful for studying the liquid state of matter. There is less known concerning liquids and solutions than of the other states of matter. Surface tension is a property of liquids and solutions and should have some connection with their structure or physical make-up. It is responsible for much of the beauty of surfaces. Since it will cause the withdrawal of sharp edges and affects the rate of fining and planing of glass, it is an important factor in commercial operations.

## II. Historical

### (1) Previous Work on the Surface-Tension Determinations of Glasses

Tillotson,[1] by weighing the drops which fell from a glass rod when heated in a blast-lamp flame, studied the surface tensions of several commercial glasses. Griffith,[2] by the use of the Quincke drop-shape method, measured the surface tensions of glasses at about 1100°C. Measurements were also made between 900 and 730°C by measuring the sag of glass fibers. Washburn and Libman[3] used a dipping cylinder method to determine the surface tensions of several glasses at 1206 and 1454°C. Lecrenier[4] used a modified form of the drop-weight method and measured the surface tensions of several glasses. Pietenpol[5] measured surface tensions of glasses at 550 to 900°C.

* Presented at the Thirty-Eighth Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Glass Division). Received September 21, 1936.

[1] E. W. Tillotson, "Surface Tensions of Molten Glasses," *Jour. Ind. Eng. Chem.*, **3**, 631 (1911); **4**, 651 (1912).

[2] A. A. Griffith, "Phenomena of Flow and Rupture in Solids," *Phil. Trans. Roy. Soc.* [London], **221A**, 163 (1920).

[3] (*a*) E. W. Washburn and G. R. Shelton, "Viscosities and Surface Tensions of Soda-Lime-Silica Glasses at High Temperatures: I, Viscosities of Glasses at High Temperatures," *Univ. Ill. Eng. Expt. Station Bull.*, No. 140, pp. 8–50 (April 14, 1924).

(*b*) E. W. Washburn and E. E. Libman, "II, Surface Tensions of Glasses at High Temperatures," *ibid.*, pp. 53–71.

Editor's Note: A detailed abstract of this reference is published in *Ceram. Abs.*, **3** [12] 336–44 (1924). Tables 10, 15, 17, 23, and 24 are given in full and Figs. 1, 2, 10, 12 to 18, and 22 are reproduced.

[4] (*a*) A. Lecrenier, "Measurement of the Surface Tension of Glass," *Bull. soc. chim. Belg.*, **33**, 119–22 (1924); *Ceram. Abs.*, **3** [9] 275 (1924).

(*b*) A. Lecrenier and P. Gilard, "Surface Tension of Molten Glass," *Bull. soc. chim. Belg.*, **34**, 27–34 (1925); *Ceram. Abs.*, **4** [7] 190 (1925).

[5] W. B. Pietenpol, "Surface Tension of Molten Glass," *Physics*, **7** [1] 26 (1936); *Ceram. Abs.*, **15** [8] 235 (1936).

## III. Apparatus and Theory of Method

### (1) Method

The maximum bubble-pressure method was used for the determination of the values reported here. Simon[6] is said to have suggested the method. Jaeger[7] developed and perfected the method for use with fused salts, etc. For this reason, the method is commonly referred to as the Jaeger method. Cantor[8] has been given credit for the first accurate theory of the method. He was also the first to use it to obtain absolute values of surface tension.

### (2) Theory of Method

When a bubble is blown at the end of a vertical tube dipping into a liquid, the bubble will have the form of a segment of a sphere if the radius of the tube is small. As the bubble is blown, the radius of this sphere will decrease until the bubble becomes hemispherical. Further growth of the bubble will cause the radius to increase. It has been proved that when the radius of the bubble is a minimum, the pressure will be at a maximum. When the radius of the bubble has a minimum value, it is hemispherical; therefore, the radius of the bubble is the same as the radius of the tube. The bubble will be unstable when it has grown beyond a hemispherical shape because the pressure decreases as more air rushes into it. From these facts, it is obvious that the maximum pressure attainable in a small tube is as follows:

$$P = P_1 + P_2 = gh_1(D - d) + \frac{2T}{r}. \qquad (1)$$

Where $P$ = total pressure in dynes/cm.$^2$
$P_1$ = $gh_1(D - d)$, hydrostatic pressure at lower end of tube.
$P_2$ = pressure necessary to overcome forces of surface tension in bubble (dynes/cm.$^2$).
$T$ = surface tension of liquid.
$r$ = radius of opening at tip of tube (inside diameter where contact angle is less than 90° and in other cases, outside diameter).
$h_1$ = depth of immersion of tube in liquid (cm.).
$g$ = acceleration of gravity.
$D$ = density of liquid.
$d$ = density of gas surrounding liquid.

This simple formula, however, is not entirely adequate as it stands, because the bubble displaces some liquid and because of the tendency of the bubble to become flattened when tubes of larger radii are used. There have been several correction terms proposed, but the best one seems to be that given by Schrödinger.[9] Adam[10] gives the equation as follows:

$$a^2 = rh\left(1 - \frac{2r}{3h} - \frac{1}{6}\left(\frac{r}{h}\right)^2 \cdots\right) = \frac{2r}{g(D - d)}. \qquad (2)$$

Dorsey[11] gives the same equation in a slightly different form as follows:

$$T = \frac{\overline{P}r}{2}\left(1 - \frac{2r}{3h} - \frac{1}{6}\left(\frac{r}{h}\right)^2 \cdots\right). \qquad (3)$$

Where $a^2$ = capillary constant (mm.$^2$).
$r$ = radius of tube opening.
$h$ = height of column of liquid equivalent to $P_2$ of (1).
$T$ = surface tension (dynes/cm.)
$\overline{P}$ = $P_2$ (dynes/cm.)

These approximate formulas are good for moderately small openings. Sugden[12] has prepared a table of correction factors which may be applied to tubes of various sizes to give the correct values.

Substitution of actual data in the above equations shows that they both give about the same values, and the values in turn check with Sugden's table. Schrödinger's formula is the easiest to use, since the $^1/_6(r/h)^2$ term is very small, and the correction is meaningless for the data presented here. The final equation as it was used in this investigation was

$$T = \frac{\overline{P}r}{2}\left(1 - \frac{2r}{3h}\right).$$

The correction depends on the extent to which the glass rises on the outside of the tip of the tube; that is, any contact angle other than zero decreases the amount of the correction. The effect of viscosity entering into the determination is ruled out since all the measurements were made at constant pressure, as will be explained later.

### (3) Surface-Tension Apparatus

The apparatus was built and used by Parmelee

[6] M. de Simon, "Research on Capillarity," *Ann. chim. phys.*, [3] **32**, 5 (1851).
[7] F. M. Jaeger, Optical Activity and High-Temperature Measurements. McGraw-Hill Publishing Co., Ltd., London (1930).
[8] M. Cantor, "Concerning Capillary Constants," *Wied. Annalen*, **47**, 399–423 (1892).
[9] E. Schrödinger, "Note Concerning Capillary Pressure in Glass Bubbles" (Notiz über den kapillaruck im Glasblasen), *Ann. Physik*, [4], **46**, 413–18 (1915).
[10] N. K. Adam, The Physics and Chemistry of Surfaces. Clarendon Press, Oxford (1930). 332 pp.; *Ceram. Abs.*, 9 [10] 887 (1930).
[11] N. E. Dorsey, "Measurement of Surface Tension," *Bur. Stand. Sci. Paper*, No. 540, 33 pp. (Nov. 24, 1926); *Ceram. Abs.*, **7** [8] 576 (1928).
[12] S. Sugden, "Determination of Surface Tension from the Maximum Pressure in Bubbles: II," *Jour. Chem. Soc.* [London], **124**, 27 (1924).

and Lyon[13] in a previous investigation. A brief description of the apparatus will be given here for the convenience of the reader.

The apparatus is shown diagrammatically in Fig. 1, in which *SR* is a stiff supporting rod which carries the adjustable furnace support, *FS*. The furnace is an electric resistance furnace, having platinum wire wound on an Alundum core. A porcelain shell protects the winding from the Sil-O-Cel insulation. The top of the furnace is an Alundum cap, with a hole of sufficient size just to admit the capillary tube and the thermocouple. The sample to be tested is held in a platinum crucible and placed in the furnace.

The platinum capillary tube is fastened securely to a holder, *H*. This holder is so constructed that, by adjusting the three screws, the plane of the circular opening of the tube can be made to become parallel with the surface of the liquid in the crucible. The holder is then clamped to the raising and lowering device actuated by the adjusting screws, *AS*. *RS* is a right-handed screw for fine adjustment. By adjusting these screws, the capillary tube can be adjusted to the proper level. This holder also carries a water-cooling coil, *CC*, which is connected to the raising and lowering device by rubber tubing. The cooling water circulates as shown in Fig. 1. The raising and lowering device is clamped securely to a stand.

The capillary tube is attached to the pressure system by sealing a piece of glass tubing to the platinum tube. This glass tube is then fastened to a piece of rubber tubing (not shown) to give flexibility to the line. The rest of the system is connected much as shown, rubber being used to make the joints. The system must be air-tight and leak-proof.

The arrangement of the pressure system is obvious from Fig. 1. The air, before entering at *N*, was reduced to a pressure of about 10 pounds per square inch. A needle valve, *N*, further regulated the flow of air. From *N*, the air passed through a drying chamber, *D*, filled with $CaCl_2$. A flowmeter, *F*, in the system helped to obtain the desired rate of flow of the air. In use, this flowmeter served to aid the operator in keeping

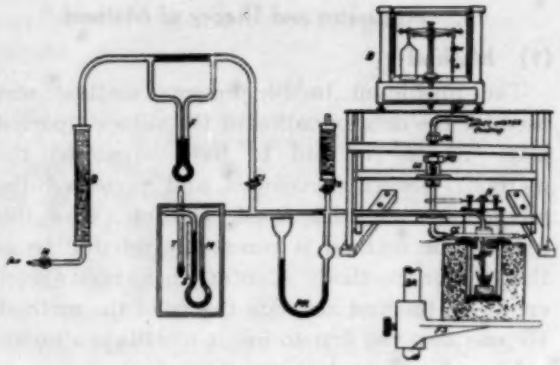

FIG. 1.—Surface tension apparatus.

the rate of air flow within safe limits. This source of air was used only in building up the pressure. When a determination was being made, the pressure was built up, then the stopcock, *C*1, was closed and final pressure adjustments were made with the movable mercury column, *PR*. The drying tube, *D*, above the stopcock, *C*2, was used to admit air to the system when *C*1 closed. The pressure regulator, *PR*, was the only feature on the apparatus not used by Parmelee and Lyon.[13] This was fitted with a holding device and adjusting screws (not shown in the diagram), which made it possible to maintain a pressure constant within ±0.005 centimeter. The manometer, *M*, was made of specially selected uniform bore-glass tubing and filled with *N*-di-butyl phthalate. The effect of capillary rise in this tube, owing to the nonuniformity of the manometer diameter, would cause a maximum error in reading less than 0.005 centimeter. The manometer was inclosed in a wooden box which was insulated with wool felt. The positions of the thermometer and scale are shown in Fig. 1. The glass tubing in the system was 8 millimeters in internal diameter. This tubing allowed no perceptible pressure lag in the system at the pressures used.

For measuring the maximum pressures obtained, the height of the liquid levels were read with a cathetometer, carefully focused to avoid parallax. The readings were always taken on the scale attached to the manometer and not on the cathetometer.

The density of the molten glass was determined by observing the loss of weight of a platinum plummet when suspended in the glass. The balance, *B*, was used for that purpose. One pan of the balance was removed, and the sus-

[13] C. W. Parmelee and K. C. Lyon, "Maximum Bubble Pressure (Jaeger); Method for Measurement of Surface Tension of Molten Glass," *Jour. Soc. Glass Tech.*, **21** [2] 44–52 (1937).

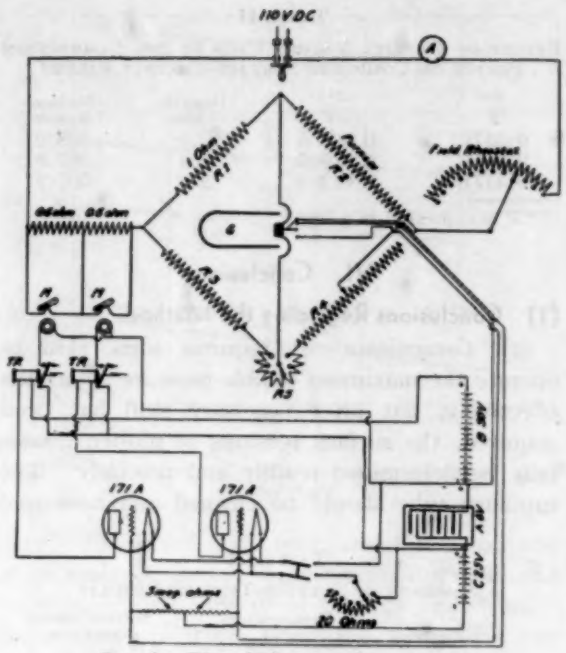


FIG. 2.—Electric furnace thermostat.

pending wire, *SW*, was used in its place. It was attached to an adjusting screw, *a*, which in turn was fastened to a counterweight, *cw*.

### (4) Temperature Regulator

The thermostat, built to regulate the temperature of the furnace, was of a type similar to that described several times elsewhere. The diagram in Fig. 2 shows the general set-up. The bridge was composed of legs *R*1, *R*2, *R*3, and *R*4; *R*5 was used to vary *R*3 and *R*4 as shown; *R*4 was made variable to match at all times the resistance of the furnace, *R*2. All resistances were made of Chromel wire, except the furnace which was platinum. Rough adjustment of the current through the furnace was made with the field rheostat. The final adjustments were made automatically by the thermostat by throwing in or out either (or both) of the 0.6-ohm resistances in series with the line.

## IV. Experimental Procedure and Technique

### (1) Preparation of the Glasses

The glasses were prepared in platinum from the purest reagent chemicals available. They were crushed and melted until they were homogeneous. A hardened steel mortar was used and the iron was removed by means of an electromagnet.

When the HCL was not completely removed from glasses which were washed in it to remove the iron (if a magnet were not used), the evolution of gas bubbles interfered with the determinations.

### (2) Procedure

The glass was held at a steady temperature of about 1375 to 1400°C until it had become essentially free of bubbles. Meanwhile, the platinum capillary tube was carefully measured and fixed in position ready for use with the plane of the opening parallel with the surface of the glass. A thermocouple was strapped to the tube, making thermal contact with the tube. Care was taken to prevent any refractory protection tubing or foreign material from contaminating the glass. As soon as the capillary tube was in place, the air pressure was turned on. This gas pressure was maintained throughout the run to prevent glass from receding into the capillary.

When ready to make a determination, the capillary was carefully lowered toward the surface of the molten glass. This was done by adjusting the screws, *LS* and *RS* (Fig. 1), until the manometer showed a sharp rise, indicating that contact had been made with the surface of the liquid. It was found necessary to leave the tube in contact with the glass for a half hour or so to allow the capillary rise of the molten glass along the tube and thermocouple wires to come to equilibrium. After this, the capillary was made just to touch the surface of the glass and measurements began.

The "minimum-maximum" bubble pressure was determined by adjusting the pressure to some value and keeping it constant until the bubble broke, then repeating at a lower pressure. When a pressure was reached such that the bubble would not break in 10 minutes but would break at a pressure 0.01 centimeter higher, that value was taken for the computation of surface tension. After this final reading was taken, the tube was raised and then lowered again to make a new contact. Successive readings never varied more than $\pm 0.5\%$. After determinations at one temperature, the furnace was cooled 50 or 75°C and held constant again until values at this temperature could be determined.

## V. Results

### (1) Identifications of Glasses and Their Compositions

The compositions of the glasses and their

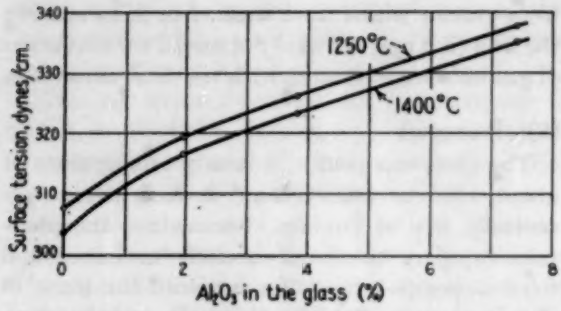


FIG. 3.—Effect of additions of $Al_2O_3$ on surface tension of glass.

numbers may be seen from Table I. The variations of $Al_2O_3$ were made by adding $Al_2O_3$ to the base glass so that the ratio $SiO_2$:$Na_2O$:MgO:CaO was the same in every glass. Washing the glasses with HCl was avoided as it was found that it caused bubbling and boiling which rendered precise determinations impossible.

TABLE I

COMPOSITION OF THE GLASSES*

| No. | $Na_2O$ (%) | CaO (%) | MgO (%) | $SiO_2$ (%) | $Al_2O_3$ (%) |
|---|---|---|---|---|---|
| S–0 | 16.02 | 7.77 | 3.02 | 73.18 | 0.0 |
| S–2 | 15.71 | 7.62 | 2.97 | 71.74 | 1.96 |
| S–4 | 15.41 | 7.48 | 2.90 | 70.37 | 3.83 |
| S–8 | 14.84 | 7.20 | 2.80 | 67.75 | 7.41 |

* Computed from batch.

### (2) Density Values

An attempt was made to determine the molten densities of the glass. These data were needed to make a final correction of the surface-tension data; but these glasses were so viscous at the temperatures used that precise determinations of the densities were not possible. The data obtained, however, were sufficient only to indicate the density of glass as approximately 2.4 at the temperatures under consideration. This appears to be sufficiently accurate as shown in Table II. The surface-tension values computed from an assumed maximum bubble pressure were calculated by assuming various density values for glass. As may be seen, the error in the assumption of a density of 2.4 for all of the glasses at all temperatures is insignificant.

### (3) Summary of Results

The surface-tension values are summarized in Table III and in Figs. 3 and 4. All of the points determined are shown, none having been discarded.

TABLE II

EFFECT OF DENSITY VALUES USED IN THE CORRECTION FACTOR ON COMPUTED SURFACE-TENSION VALUES

| $\frac{Pr^*}{2}$ | $\frac{2r}{3h}$ | Density of glass | Surface tension |
|---|---|---|---|
| 0.3171 | 0.00855 | 2.0 | 308.2 |
| 0.3171 | 0.01025 | 2.4 | 307.8 |
| 0.3171 | 0.01200 | 2.8 | 307.2 |

* $P$ is expressed in g./cm.²

## VI. Conclusions

### (1) Conclusions Regarding the Method

(*a*) *Convenience:* It requires some skill to operate the maximum bubble-pressure apparatus effectively, but after necessary skill has been acquired, the surface tensions of molten glasses may be determined readily and precisely. The capillary tube should be cleaned and measured daily, the temperature in the crucible must be uniform, and the glass must be plain. Aside from these details, a measurement of the surface tension of a glass at a single temperature may be accomplished within twenty minutes to one hour. Where many data are desired, extra capillary tubes would be advisable. Work could be considerably augmented by the use of several extra crucibles so that samples of fined and plained glasses would always be in readiness.

TABLE III

SUMMARY OF SURFACE-TENSION RESULTS

| Glass No. | Temperature (°C) | Surface tension (dynes/cm.) |
|---|---|---|
| S–0 series | 1408 | 303.0 |
| | 1408 | 304.0 |
| | 1358 | 305.1 |
| | 1330 | 305.5 |
| | 1330 | 305.9 |
| | 1288 | 307.0 |
| | 1252 | 307.1 |
| | 1226 | 308.8 |
| S–2 series | 1387 | 317.3 |
| | 1387 | 316.8 |
| | 1327 | 317.6 |
| | 1298 | 318.3 |
| | 1298 | 318.3 |
| | 1248 | 319.5 |
| S–4 series | 1350 | 323.4 |
| | 1222 | 327.0 |
| | 1248 | 325.5 |
| | 1302 | 325.0 |
| | 1390 | 324.5 |
| | 1390 | 324.4 |
| | 1302 | 324.7 |
| S–8 series | 1396 | 332.8 |
| | 1396 | 331.0 |
| | 1380 | 335.0 |
| | 1328 | 338.0 |
| | 1360 | 335.2 |
| | 1312 | 336.5 |
| | 1281 | 337.2 |
| | 1220 | 339.1 |

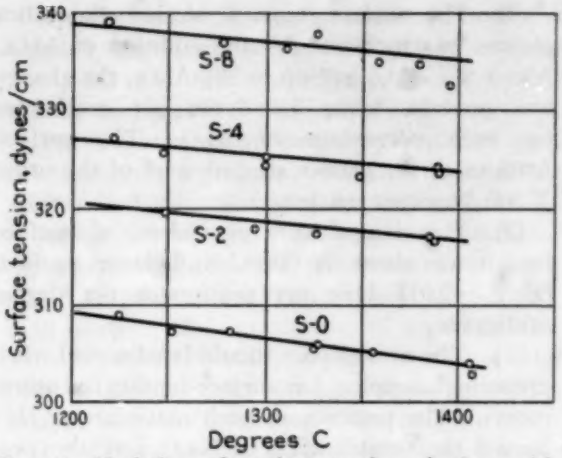


FIG. 4.—Variation of surface tension of glass with temperature.

(*b*) *Precision:* Different readings on the same material at the same temperature did not vary more than one dyne per centimeter from the average (±0.05%) and the agreement was usually about 0.5 dyne (0.17%).

(*c*) *Accuracy:* The accuracy of surface-tension measurements by this method varies somewhat, depending upon the condition of the glass. At low temperatures, below 1200°C for the glasses studied here, the surface-tension values were apparently too low. Surface-tension values will be in error if the glass has not been thoroughly fined, because of the presence of bubbles in the glass or on its surface.

### (2) Effect of Additions of $Al_2O_3$ on Surface Tensions of Soda-Lime-Silica Glasses

The manner in which the surface tensions of soda-lime-silica glasses varied with the addition of $Al_2O_3$ is shown in Fig. 3. The slope of this curve decreases with increasing $Al_2O_3$. This change in slope is rapid at first, but after the $Al_2O_3$ content reaches about 2%, the decrease in the slope of the curve is much less. The average increase in surface tension between 1.96% $Al_2O_3$ and 7.4% $Al_2O_3$ was 18.6 dynes per centimeter at the same temperature. This amounts to an increase of 3.4 dynes per centimeter for each percentage addition of $Al_2O_3$. Thus, in the range of compositions studied for 0.1% increase of $Al_2O_3$, the surface tension increased 0.34 dyne per centimeter.

### (3) Effect of HCl on Glasses Prepared for Surface-Tension Studies

Some glasses were made up which were washed with HCl after each melting and crushing. It was found that the HCl was incompletely removed after treatment. The presence of the HCl caused loss of $Na_2O$ as NaCl by aqueous solution and by volatilization when heated. Visual evidence during tests and subsequent analysis proved this to be so. The compositions of these glasses changed during the measurement of surface tension so that the points were badly scattered. It was evident from this experience that, if surface tension is to be studied as a function of composition, the composition must be rigorously controlled.

Great difficulty was encountered in freeing the glasses containing chlorine from bubbles. It took a long period of time, and there was a likelihood of the glass boiling over. In some cases, the entire sample of glass would boil out of the crucible. Even after these glasses were apparently fined, bubbles would appear when reheated, rendering precise measurement of surface tension impossible.

### (4) Comparison of Data with That of Other Investigators

A direct comparison of these results with those of other investigators can not be made owing to the difference in compositions of the glasses studied. A comparison of the order of magnitude of the various values, in most cases, will serve to show whether or not the data are in substantial agreement.

Griffith[2] chose a glass with the following percentage composition.

| | | | |
|---|---|---|---|
| $SiO_2$ | 69.2 | CaO | 4.5 |
| $Na_2O$ | 0.9 | MnO | 0.9 |
| $Al_2O_3$ | 11.8 | $K_2O$ | 12.0 |

His results were as follows:

| Temp. (°C) | 1100 | 905 | 896 | 852 | 833 | 820 | 801 | 760 | 745 |
|---|---|---|---|---|---|---|---|---|---|
| Surface tension (dynes/cm.) | 403 | 418 | 438 | 436 | 445 | 436 | 450 | 446 | 439 |

The temperatures are all lower than those of the present investigation, but the values are of about the same magnitude as those reported in this work.

One of the glasses studied by Washburn and Libman[3] had a composition of $SiO_2$ 73.5%, CaO 10%, and $Na_2O$ 16.5. This is close to the composition of the base glass used in this investigation. The values reported for this glass were as follows:

| Temp. (°C) | 1206 | 1456 |
|---|---|---|
| Surface tension (dynes/cm.) | 166.9 | 159.4 |

These values are much lower than those obtained in this investigation.

Lecrenier[4] reports values for soda-lime-silica glasses of the order of about 450 to 500 dynes per centimeter.

Parmelee and Lyon,[13] with the same apparatus as used in the present study, investigated some soda-boric oxide-silica glasses. Only a general comparison is possible with their data because of the difference in composition, but they are in substantial agreement with the data reported here.

Pietenpol,[5] by his bulb method, obtained values that appear to be in general agreement with those obtained by the maximum bubble-pressure method.

## VII. Summary

(1) The maximum bubble-pressure method has proved to be well adapted to the study of the surface tension of molten glasses. Its precision is at least ±0.5% and may be made to perform better than that.

(2) The surface tension of soda-lime-silica glasses was increased by the addition of $Al_2O_3$. Above 2% $Al_2O_3$ and up to 8% $Al_2O_3$, the change was gradual, being 3.4 dynes per centimeter for each percentage of $Al_2O_3$. The surface tensions of the glasses studied were of the order of 300 dynes per centimeter.

(3) The temperature coefficient of surface tension was about the same for all glasses studied, being −0.017 dyne per centimeter per degree centigrade.

(4) The utmost care should be observed when preparing samples for surface-tension measurements. The presence of such materials as HCl caused the volatilization of $Na_2O$ and also produced many bubbles.

(5) It was difficult to measure the specific gravity of viscous glasses. The loss in weight of a platinum sphere when suspended in the glass, did not give satisfactory results.

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# ANALYSIS OF FELDSPAR—DETERMINATION OF FERRIC OXIDE: I, DECOMPOSITION OF SAMPLE*

By E. W. Koenig

Abstract

A modified method for the decomposition of the feldspar sample, preliminary to the determination of percentage ferric oxide, is described.

## I. Introduction

Regardless of the method chosen for the actual determination of percentage ferric oxide in silicate materials, the accuracy of the determination is greatly dependent upon the choice of the method for the initial decomposition of the sample. A method applicable to one type of silicate is often unsuited to one of a different mineralogical composition.

The method most popular for the determination of trivalent iron in feldspar depends upon the solution of the sample in hydrofluoric and sulfuric acids, evaporation of the resultant solution to dryness, and resolution of the residue in dilute hydrochloric acid. The residue is never completely soluble and the insoluble portion must be fused with potassium pyrosulfate and added to the main solution. The platinum introduced during the digestion and solution must be removed with hydrogen sulfide, and the hydrogen sulfide free-filtered solution used for the estimation of iron. This latter step is tedious, but necessary; disregard of the effect of platinum is dangerous[1] because of the variable amount introduced during the solution of the sample. Lyle[2] confirmed this earlier work of the effect of platinum and showed that the greater part of this interference was introduced during the pyrosulfate fusion. By the substitution of vitreous silica crucibles for those of platinum previously used for this fusion, he was able to reduce the interference to a constant of small value. Excellent results are to be obtained by this modification.

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Materials and Equipment Division). Received December 17, 1936.

[1] G. E. F. Lundell and H. B. Knowles, "The Determination of Iron in Glass Sands," *Jour. Amer. Ceram. Soc.*, 11 [3] 119–25 (1928); p. 121.

[2] A. K. Lyle, "Notes on Electrometric Iron Determination: Iron in Feldspar," *ibid.*, 15 [6] 334–37 (1932).

The evaporation of the hydrofluoric-sulfuric acid solution, the fuming to drive off the last of the free acid, and the resolution in dilute hydrochloric acid are time-consuming and require an excessive amount of personal attention. In laboratories where a great many iron determinations are required, it is essential, for reasons of economy of time and equipment, that a method capable of rapid derivation of results with no material sacrifice in accuracy or precision be used.

Rowledge[3] used a mixture of equimolecular parts of sodium fluoride and anhydrous boric acid, $(NaF)_2B_2O_3$, as a flux for the decomposition of the sample. Results by the use of this reagent, in the writer's laboratory, indicated complete decomposition, but the preparation of the flux and the solution of the melt proved rather troublesome. Vickers[4] suggested the fusion of the sample with sodium carbonate, removal of silica after evaporation and dehydration, precipitation of the mixed oxide group with ammonia, and the determination of iron in the solution of this precipitate in a mineral acid. This procedure is quite impractical for feldspar because of the preponderance of alumina.

The use of sodium hydroxide as a flux for the decomposition of glass sands preliminary to the determination of ferric iron was advocated by Skinner.[5] Treatment of the water solution of the melt with sodium sulfide separated the iron as sulfide and, after filtration and solution in hydrochloric acid, the iron was precipitated as hydroxide with ammonia. The hydrochloric acid solution of this precipitate was used for the determination of trivalent iron. This procedure is somewhat involved and requires a prohibitive amount of personal attention, though the results obtained show a good degree of precision.

Hackl[6] showed that certain silicates can be decomposed completely in a mixture of hydrofluoric and sulfuric acids and that the excess hydrofluoric acid will form the inactive complex, $HBF_4$, when treated with an excess of boric acid. This was confirmed by Soule,[7] who substituted hydrochloric acid for the sulfuric acid. The writer's work on the decomposition of the feldspar sample for the determination of the alkalis[8] showed that this silicate is completely soluble in hydrofluoric acid alone. This test indicated that, unless complications due to platinum arose, a simplification of existing methods might be possible.

## II. Reagents

Reagents were chosen with care to reduce the amount of "blank" iron to a minimum.

### (1) Hydrofluoric Acid, 48%

A specially prepared reagent marketed as "low in iron" was used. Analyses of several lots indicated a mean value of 0.00008% $Fe_2O_3$, a high value of 0.00021%, and a low of 0.00002%. This illustrates the necessity of frequent checks upon the purity of this reagent. To eliminate the need for tests upon a great many small lots, several portions can be combined and stored in ceresin-lined bottles. The reagent could, perhaps, be further purified by redistillation.

### (2) Sulfuric Acid 1:1

A reagent grade was diluted with distilled water and was found to be practically free of iron.

### (3) Boric Acid

A reagent grade was found to be iron-free.

## III. Experimental

Three grams of the −200-mesh sample are transferred to a 100-milliliter platinum dish (a "Payne"-type dish is particularly suitable) and moistened with a few drops of water or alcohol. The latter is preferable because of its apparent reduction of surface tension during the subsequent decomposition. Twenty milliliters of hydrofluoric acid are added and the sample is brought to solution by stirring with a platinum rod and the application of heat. The reaction is rapid. When completely in solution, it is transferred quantitatively with water to a 500-milliliter Erlenmeyer

[3] H. P. Rowledge, "New Method for Determination of Ferrous Iron in Refractory Silicates," *Jour. Roy. Soc. W. Australia*, **20**, 165–99 (1934).

[4] A. E. J. Vickers, "Determination of Iron in Silicates," *Trans. Ceram. Soc.* [Eng.], **27** [3] 156–60 (1927–28); *Ceram. Abs.*, **8** [7] 529 (1929).

[5] L. B. Skinner, "Thiosulphate Titrations of Small Amounts of Iron in Glass Sands," *Ind. Eng. Chem., Anal. Ed.*, **3** [4] 411–14 (1931); *Ceram. Abs.*, **11** [4] 274 (1932).

[6] O. Hackl, "Direct Determination of Tervalent Iron in Acid-Insoluble Silicates; Accuracy of Method for Determining Valency of Iron by Attacking Silicate with Hydrofluoric and Sulfuric Acids" (Die Directe Bestimmung des Dreiwertigen Eisens in Saureunloslichen Silicaten. Über die Genauigkeit der Verfahren zur Bestimmung der Wertigkeitsstufen des Eisens bei der Aufschliessung mittels Flussaure-Schwefelsaure), *Z. anal. Chem.*, **66**, 401–30 (1925); *Ceram. Abs.*, **4** [12] 359 (1925).

[7] B. A. Soule, "Determination of Ferrous Iron in Silicate Rocks: II, Electrometric," *Jour. Amer. Chem. Soc.*, **51** [7] 2117–20 (1929); *Ceram. Abs.*, **8** [12] 926 (1929).

[8] E. W. Koenig, "Determination of Alkalis in Feldspar," *Ind. Eng. Chem., Anal. Ed.*, **7** [5] 314–15 (1935); *Ceram. Abs.*, **15** [1] 43 (1936).

flask containing a solution of 10 grams boric acid, 50 milliliters 1:1 sulfuric acid, and 100 milliliters of water.

A modification of this procedure, which has found favor in this laboratory, consists of evaporating the sample (alcohol-hydrofluoric acid) solution to dryness on the water bath, quantitatively transferring the residue to a 250-milliliter flask containing a solution of 2 grams of boric acid, 50 milliliters 1:1 sulfuric acid, and 50 milliliters of water. This procedure eliminates the handling of the hot hydrofluoric acid solution and, though not as rapid as the first method, the smaller volume gives sharper end-points in permanganic or titanometric determinations. The further treatment is identical regardless of the modification used for the decomposition.

The solution obtained as described was brought to a boil, the iron reduced with an excess of stannous chloride and titrated, hot, electrometrically[9] with an approximately 0.005*N* dichromate solution which had been previously standardized against ferric chloride.

A second series of samples was decomposed in the manner suggested by Lyle,[2] the insoluble residue being fused with pyrosulfate in silica, and the trivalent iron was determined as above. In both series of titrations, the air in the titration flask was displaced by carbon dioxide scrubbed through a concentrated solution of copper sulfate. Comparative results are shown in Table I.

Comparison of the results shown in Table I are indicative of the excellence of the results to be obtained by the present modification. The average correction to be applied to the results obtained by the modified procedure is somewhat in the order of one-third of that required by the usual pyrosulfate-fusion method.

Inasmuch as attempts to make direct determinations of the "blank" electrometrically gave results of poor precision, the colorimetric method of Yoe[10] was used to determine the amount of iron carried by the reagents. This method gave fairly concordant results. The pyrosulfate method showed a value of 0.00010 gram $Fe_2O_3$ and the $HF–H_3BO_3$ method 0.000046 gram $Fe_2O_3$, the difference being introduced, in all probability, by the pyrosulfate and hydrochloric acid used in the former method. These values do not agree exactly with the corrections indicated above, perhaps owing to the presence of a small amount of platinum. In an effort to determine if this premise were true, 200 milliliters of hydrofluoric acid were evaporated to dryness in a platinum dish and the residue was treated in the manner prescribed by Hahn[11] for the qualitative detection of platinum. A rather indefinite reaction was obtained. This, of course, would not take into account the solution of platinum by the hot ferric chloride present under the former conditions of solution of sample and, by the same token, may account for the larger divergence between "blank" iron and average difference in results by the older method.

## IV. Discussion

The data shown indicate that concordant results are to be obtained by the proposed modification and that the average difference between apparent and true results is somewhat less than by the pyrosulfate method ordinarily used for this determination.

Results prove that the method is not conducive to high "platinum effect." The method is inexpensive and allows a more rapid derivation of results than the one ordinarily employed.

It was found that certain precautions were

TABLE I

| $Fe_2O_3$ present (3 g. sample) | $Fe_2O_3$ by pyrosulfate (g.) | Difference (g.) | Corrected by av. difference (%) | Error (%) | $Fe_2O_3$ by $HF–H_3BO_3$ (g.) | Difference (g.) | Corrected by av. difference (%) | Error (%) |
|---|---|---|---|---|---|---|---|---|
| 0.0020 | 0.00217 | 0.00017 | 0.067 | 0.000 | 0.00207 | 0.00007 | 0.067 | 0.000 |
| .0018 | .00195 | .00015 | .060 | .000 | .00184 | .00004 | .060 | .000 |
| .0014 | .00156 | .00016 | .046 | .000 | .00144 | .00004 | .046 | .000 |
| .0010 | .00114 | .00014 | .033 | .000 | .00105 | .00005 | .033 | .000 |
| .0009 | .00102 | .00012 | .029 | −.001 | .00095 | .00005 | .030 | .000 |

Av. difference pyrosulfate 0.00015 g. Av. difference $HF–H_3BO_3$ 0.00005 g.

[9] J. C. Hostetter and H. S. Roberts, "Electrometric Titrations with Special Reference to the Determination of Ferrous and Ferric Iron," *Jour. Amer. Chem. Soc.*, **41**, 1337–57 (1919).

[10] J. H. Yoe, "7-Iodo-8-Hydroxyquinoline-5-Sulphonic Acid as a Reagent for Colorimetric Determination of Ferric Iron," *ibid.*, **54**, 4139–43 (1932).

[11] Friederich Hahn, "Microcatalytic Detection of Platinum Metals," *Microchemie*, **8**, 77–80 (1930).

necessary; briefly, they are (1) the sample must be finely ground; samples coarser than 200-mesh are more difficult to bring into solution than those of a finer state of division.

(2) An excess of boric acid must be present to insure complete conversion of free HF to $HBF_4$. Free HF does not reduce $K_2Cr_2O_7$, even in hot solution, but the attack upon the glassware is rather severe.

## V. Conclusion

A method for the rapid decomposition of the feldspar sample preliminary to the determination of trivalent iron is described. Data are given to show the precision of the method.

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# THE ANALYSIS OF FELDSPAR—DETERMINATION OF FERRIC OXIDE: II, APPLICATION OF TITANOMETRY*

BY E. W. KOENIG

ABSTRACT

The application of titanometric methods of analysis to the estimation of trivalent iron in feldspar is advocated.

## I. Introduction

When a titanous chloride solution is added to an acid solution of ferric iron, the following reactions take place:

$$FeCl_3 + TiCl_3 = FeCl_2 + TiCl_4$$
$$Fe_2(SO_4)_3 + 2TiCl_3 + 3H_2SO_4 = 2FeSO_4 + 2Ti(SO_4)_2 + 6HCl$$

These reactions form the basis for the well-known Knecht and Hibbert titanometric procedure for the determination of iron. This method has never achieved the popularity it deserves because of the rapid atmospheric oxidation of titanous solutions unless protected, during storage and delivery, by a nonoxidizing gas or other means to exclude air. Solutions in the range of 0.005 to 0.1*N* show a greater tendency to atmospheric oxidation than do those of higher concentration.

Despite this serious objection, the method has certain advantages over others used for the determination of percentage ferric oxide in the amounts found in ceramic materials. When used with an internal indicator, a more rapid derivation of results is possible than by the electrometric method commonly used[1] with the added advantage of titrating at room temperatures. Brandt[2] has shown that the interference due to platinum is far less in titanometric procedures than when oxidizing solutions are used. Hydrochloric acid solutions can be used without the necessity of special precautions, an advantage over the permanganate procedure. The complications brought about by the addition of mercuric chloride often found in methods using potassium dichromate or ceric sulfate as oxidizing agents are nonexistent in titanometric procedures. The complete removal of free hydrofluoric acid as such is unnecessary; conversion to fluoboric acid with an excess of boric acid precludes any reaction of the fluorine ion.[3] This is not the case with most colorimetric methods, particularly the thiocyanate procedure,[4] nor does the aluminum interfere as in the colorimetric procedure employing 7-iodo–8-hydroxyquinoline–5-sulfonic acid.[5] Finally, the elements which interfere, *i.e.*, copper, antimony,

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[1] A. K. Lyle, "Notes on Electrometric Iron Determination: Iron in Feldspar," *Jour. Amer. Ceram. Soc.*, **15** [6] 334–37 (1932). See also J. C. Hostetter and H. S. Roberts, Jr., "Electrometric Titration with Special Reference to Determination of Ferrous and Ferric Iron," *Jour. Amer. Chem. Soc.*, **41**, 1337–57 (1919).

[2] L. Brandt, "Volumetric Determination of Iron with Titanium Chloride by the Method of Knecht and Hibbert" (Über die massanalytische Eisen Bestimmung mit Titanchlorid nach Knecht und Hibbert), *Chem.-Ztg.*, **52**, 270–71 (1924).

[3] O. Hackl, "Direct Determination of Tervalent Iron in Acid-Insoluble Silicates; Accuracy of Method for Determining Valency of Iron by Attacking Silicate with Hydrofluoric and Sulfuric Acids" (Die Directe Bestimmung des Dreiwertigen Eisens in Saureunloslichen Silicaten. Über die Genauigkeit der Verfahren zur Bestimmung dei Wertigkeitsstufen des Eisens bei der Aufschleissung mittels Flussaure-Schwefelsaure), *Z. anal. Chem.*, **66**, 401–30 (1925); *Ceram. Abs.*, **4** [12] 359 (1925).

[4] W. F. Hillebrand and G. E. F. Lundell, Applied Inorganic Analysis, p. 310. John Wiley & Sons, 1931.

[5] Unpublished results of the author.

cobalt, nickel, vanadium, and platinum, are not likely to be found in the analysis of feldspar.

The application of titanometry to the estimation of small amounts of iron offered so many apparent advantages that a study of available methods of storage of titanous solutions was indicated. Most of the applications made use of hydrogen or carbon dioxide as the nonoxidizing seal, although MacFarlane[6] used metallic mercury with excellent results in the analysis of biological material for iron. Schollenberger[7] devised a novel hydrogen generator with an accessory burette and container which is very compact. Unfortunately, no means of scrubbing the gas was incorporated in the equipment. The same criticism can be applied to the apparatus illustrated by Scott.[8] Smith and Sullivan[9] reported excellent stability of relatively weak solutions when stored in a Zintl-Reinacker apparatus with automatic burette.[10] A similar apparatus was finally chosen for the present research.

## II. Reagents

The titanous chloride can be prepared by the method of Bray, Simpson, and McKenzie,[11] if desired. First trials in this research used this method with excellent results. A more convenient procedure entails the addition of 50 milliliters of the commercial 20% solution[12] to 450 milliliters of boiling concentrated hydrochloric acid and dilution to 9 liters, the capacity of the container in the present instance. It is essential that no air be trapped in the container and that the solution be well mixed and kept out of direct sunlight; a dark container is recommended. It is well to "age" the solution for a day or two before use to insure equilibrium. Early in the work it was found that the titer of the solution changed rapidly despite a constant hydrogen pressure. This was finally corrected by scrubbing the gas, generated by the action of hydrochloric acid upon zinc, successively through alkaline pyrolgallol, saturated mercuric chloride, and dilute sulfuric acid. This train, with the addition of potassium permanganate, has been recommended for the purification of hydrogen for $p_H$ measurements with the hydrogen electrode.[13] The titer of the solution was checked at frequent intervals against a standard ferric chloride solution and electrometrically.[14] Table I shows the relative stability of the solution.

TABLE I

| | 10 days | 30 days | 60 days | 90 days |
|---|---|---|---|---|
| Normality | 0.00375 | 0.00373 | 0.00373 | 0.00370 |

### (1) Ammonium Thiocyanate, 25%

This reagent carries the greater amount of "blank" iron introduced during the analysis. Without purification, the reagent contains nearly 0.0005% Fe and, if used as received, would introduce an appreciable error unless the proper correction was applied. The reagent can be purified by conversion to thiocyanic acid and extraction of the iron with ether and amyl alcohol.[15] It has been suggested that the iron in the reagent can be reduced with titanous chloride, measuring the rate of the reduction potentiometrically to overcome this interference.[16]

## III. Experimental Procedure

Three-gram samples of feldspar, which had been standardized by electrometric means and containing from 0.09 to 2.0 milligram $Fe_2O_3$, were decomposed in the manner previously described,[17] and the resultant solutions were treated with an excess of potassium permanganate to oxidize the ferrous iron. The excess was removed by boiling to the expulsion of the pink color. The solutions were cooled to room temperature (26°C), treated with 5 milliliters of the purified HCNS, and the air in the flask was displaced with $CO_2$ which had been scrubbed through a solution of $CuSO_4$. With the flow of the gas continued, the standard titanous solution was added slowly, drop by drop, the tip of the burette inserted in a hole in the stopper, with constant shaking to the disappearance of the

[6] W. D. MacFarlane, "Determination of Iron by Titanometry and *a-a'*Bipyridine," *Ind. Eng. Chem., Anal. Ed.*, **8**, 124–26 (1936).

[7] C. S. Schollenberger, "Buret Assembly for Standard Reducing Solutions," *ibid.*, **7**, 199 (1935).

[8] W. D. Scott, Standard Methods of Chemical Analysis, p. 238. D. Van Nostrand & Co., New York, N. Y.

[9] G. F. Smith and V. R. Sullivan, "Volumetric Determination of Iron in Leather," *Ind. Eng. Chem., Anal. Ed.*, **7**, 301–305 (1935).

[10] G. F. Smith, Ceric Sulphate, Vol. 1, 2d ed., p. 60. G. Frederick Smith Chemical Co., Columbus, Ohio, 1933.

[11] Wm. Bray, M. E. Simpson, and A. A. McKenzie, "Volumetric Determination of Hydroxylamine," *Jour. Amer. Chem. Soc.*, **41**, 1363–78 (1919).

[12] LaMotte Chemical Co.

[13] Anon., Notes on $p_H$ Measurements. Leeds and Northrup Note Book No. 3, Philadelphia, Pa., 1931.

[14] A. McMillan, "Electrometric Titration with Special Reference to Use of Titanous Chloride for Ore Analysis," *Jour. Soc. Chem. Ind.*, **44**, 141–42T (1925).

[15] H. L. Smith and J. H. Cooke, "Determination of Very Small Amounts of Iron," *Analyst*, **51**, 503–10 (1926).

[16] G. Frederick Smith, private communication.

[17] E. W. Koenig, "Analysis of Feldspar—Determination of Ferric Oxide: I, Decomposition of Sample." See this issue, pp. 230–33.

pink color. End-points were easily detected. The results obtained are shown in Table II.

TABLE II

| $Fe_2O_3$ present (g.) | $Fe_2O_3$ found (g.) | Difference | Corrected by av. difference (%)* | Error |
|---|---|---|---|---|
| 0.0020 | 0.00207 | 0.00007 | 0.067 | 0.000 |
| .0018 | .00186 | .00006 | .060 | .000 |
| .0014 | .00146 | .00006 | .047 | .000 |
| .0010 | .00106 | .00006 | .033 | .000 |
| .0009 | .00096 | .00006 | .030 | .000 |

* Average difference 0.00006 g.

The data indicate an average difference closely approximating that found for the decomposition itself.[17] This implies that the indicator was practically free of iron.

To determine the optimum conditions for the titration, several variations were attempted. The results will be described briefly.

(1) Acidity can be varied from 10 to 90%, in terms of sulfuric acid, and with no apparent difference of precision.

(2) Titrations conducted at temperatures varying from 20° to 50°C give identical results. This is at variance with the views of Emmet,[18] who cautions against higher temperatures than the surroundings. Temperatures above 50°C cause indistinct end-points.

(3) The rate of addition of $TiCl_3$ is of the greatest importance, particularly near the end-point. If added too fast, an excessive amount of the reductant is used. Toward the end of the reaction, which is very apparent from the fading of the color, the reductant should be added at the rate of one or two drops every 30 seconds with constant shaking.

(4) It was found that titrations conducted without the use of a head of carbon dioxide in the titrating flask are, for all practical purposes, as accurate as those in which the titanous solution does not come in contact with the air in the flask during delivery.

(5) It was also found that good precision is obtained with the ammonium thiocyanate reagent used as received if correction is made for the iron carried by the reagent. The reagent used during this research required a correction of 0.00003 gram in addition to the average correction found for the decomposition of the sample.

(6) Titrations must be conducted directly after the addition of the indicator because of the gradual fading of the color in ordinary daylight.

(7) In one series of samples, a peculiar tint was obtained upon addition of the indicator, and the end-point found upon titration was so indistinct as to be valueless. The reason for this abnormal behavior was traced to the lack of sufficient boric acid to convert the excess hydrofluoric acid to fluoboric acid.

(8) Although the thiocyanate reaction is quite definite, several other indicators were used in an effort to eliminate the time factor present in the former reaction. Methylene blue was found to be valueless. The chromic acid salt of diphenylcarbazide[19] allows the reaction to proceed at a more rapid rate with no loss in precision, though an indicator correction apparently is necessary. The instability of the indicator would prove a handicap in routine determinations.

## IV. Discussion

The data shown indicate that the method described for the determination of trivalent iron in feldspar offers definite advantages over methods now commonly employed. The precision and accuracy of the determination is comparable to that of the electrometric method with the advantage of a more rapid derivation of results. The cost of equipment and reagents is low. The almost complete freedom from the interference of certain factors found in other methods of analysis is of value.

## V. Conclusion

The use of a titanometric method for the determination of ferric iron in feldspar has been investigated and data are given to show its adaptability, precision, and accuracy.

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[18] W. G. Emmet, "Use of Titanous Chloride in Volumetric Estimation of Copper and Iron," *Jour. Chem. Soc.*, pp. 2059–62 (1927).

[19] L. Brandt, "Determination of Iron by Means of Titanium Trichloride in the Presence of Copper" (Ein Verfahren Eisen Bestimmung mit Titantrichlorid bei Gegenwart von Kupfer), *Stahl u. Eisen*, **46**, 976–81 (1926).

# INTEGRAL EXPANSION OF VITREOUS ENAMELS BETWEEN THE SOFTENING POINT AND ROOM TEMPERATURE*

By J. E. Rosenberg and A. Langerman

Abstract

The differential expansion of vitreous enamels and base metal is estimated from the mechanical properties of a closed ring of the sheet metal covered on the outside with enamel. An equation is derived relating the tangential static force necessary to overcome the stress in the ring to the coefficient of expansion and elastic properties of the enamel. The equation is reduced to linear form and a plot gives accurately $(\alpha s - \alpha e)\Delta T$, where $\alpha s$ and $\alpha e$ are, respectively, the average coefficients of the steel and the enamel in the temperature interval, $\Delta T$, between the softening point of the enamel and room temperature. The results by this method are in good agreement with those obtained by interferometer measurements.

## I. Introduction

It has been previously stated that in order to make use of the coefficient of expansion of vitreous enamel, it is necessary to know the total expansion of the enamel from its softening point to room temperature. The difference between this integral expansion and that of steel in the same temperature interval gives an indication of the mechanical stress to which enamel on steel is subjected. It is believed that the ring method previously described[1] gives a measure of the stress in the enamel. Some modifications in the apparatus have been made, particularly in the construction of the ring and, as now presented, the accuracy compares favorably with that of other methods used to measure the coefficient of expansion. The results, however, are not directly comparable with those obtained by means of the interferometer or the direct expansion of a rod.

In this method, the differential contraction is measured from the softening point to room temperature, which is the reverse of the usual methods. This difference is important. Metals, for example, undergo a permanent increase in length after a critical temperature has been reached, so that the coefficient of expansion on cooling from this temperature is less than the coefficient on heating. The creeping of metals at elevated temperature is due to this phenomenon. It would be interesting to compare the expansion and contraction of vitreous enamels on heating and cooling by the interferometer method. Such studies have been made for glasses.[2]

Up to the present time, little use has been made of the coefficient of expansion as evidenced by the fact that the value for the cubic coefficient is used. In any calculation in which the coefficient of expansion would be used to calculate the mechanical stress on the enamel, the value for the linear coefficient would be used. Part of the difficulty has been due to the fact that the expansion measured and the factors used did not give true values for the entire temperature interval. The factors no doubt are accurate, but they are based on data obtained on the expansion between room temperature and about 100°C. That range is only about one-fifth of the temperature interval between the softening point and room temperature and is often misleading. To cite perhaps an extreme case, Andrews and Howe[3] give the results

Table I

| Enamel No. | Av. cu. coefficient (room temp. to 100°C) | Av. cu. coefficient (20°–475°C) |
|---|---|---|
| 1 | $334 \times 10^{-7}$ | $445 \times 10^{-7}$ |
| 9 | 361 | 413 |
| 18 | 337 | 394 |

of some accurate measurements with the interferometer on a series of enamels which were used to obtain factors for the calculation of the coefficient of expansion from the chemical composi-

* Presented at the Thirty-Eighth Annual Meeting, American Ceramic Society, Columbus, Ohio, April 1, 1936 (Enamel Division). Received October 17, 1936.

[1] J. E. Rosenberg and A. Langerman, "Method and Apparatus for Studying Physical Properties of Vitreous Enamels on Steel," *Jour. Amer. Ceram. Soc.*, **19** [3] 86–90 (1936).

[2] (*a*) A. Q. Tool, D. B. Lloyd, and G. E. Merritt, "Dimensional Changes Caused in Glass by Heating Cycles," *ibid.*, **13** [9] 632–54 (1930); *Bur. Stand. Jour. Research*, **5** [3] 627–46 (Sept., 1930); R. P. 219.

(*b*) A. Q. Tool and C. G. Eichlin, "Variations Caused in Heating Curves of Glass by Heat Treatment," *Jour. Amer. Ceram. Soc.*, **14** [4] 276–308 (1931); *Bur. Stand. Jour. Research*, **6** [4] 523–52 (1931); R. P. 292.

[3] A. I. Andrews and E. E. Howe, "Effect of Fluorides on Properties of White Sheet-Iron Enamels," *Jour. Amer. Ceram. Soc.*, **17** [10] 288–91 (1934).

tion. In Table I are given three of the series of enamels and their expansion rate in the low and high temperature range.

What is actually important is the high temperature range. The factors used are usually based on the expansion between room temperature and 100°C. From these figures, conclusions were made that enamels Nos. 1 and 18 had about the same expansion rate, No. 18 being slightly higher, while for the entire temperature interval between the softening point and room temperature, No. 18 is much lower than No. 1. The enamel having the highest value for the coefficient of expansion at the low temperature interval proves to be much lower than No. 1, although higher than No. 18 at the higher range. It is therefore easy to understand why coefficient of expansion factors have found only a limited application in the field of vitreous enamels and why a correlation between this physical property and others has not been found.

While it may be desirable to have a value for the coefficient of expansion of an enamel in any temperature interval, the important quantity is the total expansion of the enamel between its softening point and room temperature. The method used in this study does not give this value directly, nor do the measurements give the relative values, because Young's modulus may be different for every enamel. But this method does measure directly the effect which is due to the difference in the total expansion and the moduli of elasticity of the enamel and the steel.

## II. Apparatus

The apparatus is simple and consists essentially of two parts, the rings and the device for applying the force sufficient to part the ends of the ring. Modifications in the apparatus previously described[1] have been made and a complete description is given here. For convenience the laboratory dimensions of the apparatus are used.

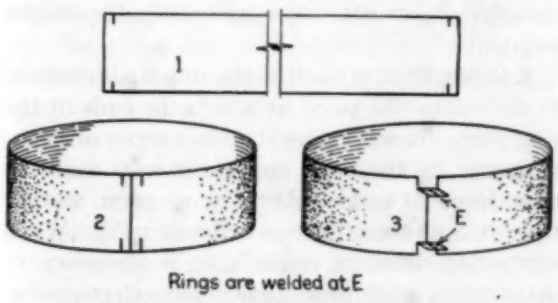


FIG. 1.—Construction of rings.

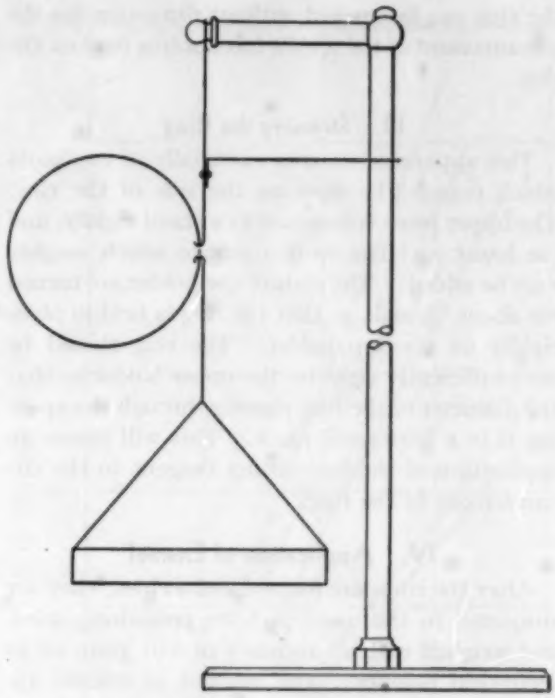

FIG. 2.—Apparatus for determining stress in enameled ring.

### (1) The Rings

To make the results of a series of measurements comparable, the rings must be as nearly identical as possible in diameter, width, and thickness. Since the force on the ring increases with the width and thickness of the steel, these must be accurately uniform. Sheets of 20-gage vitreous enameling stock are selected to obtain a uniform thickness of 0.034 ± 0.0005 inch. These sheets are then cut accurately into rectangular strips 8.42 inches long and 1 inch wide. At $\frac{1}{8}$ inch from each end, a cut $\frac{1}{4}$ inch long is made on both sides of the strip at right angles to the length. The strip is bent into an approximate circle and then placed in a die for accurate forming. The die exactly accommodates the strip used.

After the ring is formed, the cut ends in the strip are bent so that they project radially from the ring. These projecting strips are welded to hold the ring closed during the application and firing of the enamel (Fig. 1).

After the ring has been enameled, these projections are ground off on an emery wheel, and

the ring can be opened without distortion for the measurement of the tensile force acting to close the ring.

### III. Stressing the Ring

This apparatus consists essentially of two parts which engage the slots on the side of the ring. The upper piece is fastened to a stand rigidly, and the lower part has on it a pan to which weights may be added. The ends of the holder are turned for about $^1/_4$ inch, so that the ring is held in place rigidly on the top holder. The ring should be held sufficiently tight by the upper holder so that the diameter of the ring passing through the opening is in a horizontal plane. This will insure an application of the force being tangent to the circumference of the ring.

### IV. Application of Enamel

After the rings are formed and welded, they are subjected to the usual pickling procedure, dried, and weighed with an accuracy of 0.01 gram on an analytical balance. The amount of enamel applied to the ring is determined by weighing the ring after the enamel has been thoroughly dried. The enamel is applied either by spraying or dipping. When it is to be applied equally on both sides, it is usually dipped, and it is sprayed when the application is used only on one side. The spraying is done with relatively dry enamel to avoid a bead on the edge. The rings are sprayed on a turntable or banding wheel to insure uniform application and are fired by laying them horizontally on the firing bars.

It was found impractical to apply all of the enamels directly on iron. A series of tests was made, accordingly, to determine the effect of ground coat. It is important that the application should be equal on the outside and inside; otherwise there will be a stress on the ring owing to the difference in the thickness of the ground coat on the two sides.

### V. Effect of the Gound Coat

Steel rings were dipped into a commercial ground-coat enamel and the rings were shaken but not revolved, so that the enamel would be the same both on the inside and outside. The enamel was then thinned and another set of rings was dipped. This was repeated until there were four different weights of enamel. The weight of the dried enamel was determined and the rings were fired. On all of these rings the same weight of cover-coat enamel was applied and the rings were fired. The force measured on these rings showed that after a minimum weight of ground-coat enamel was applied, the force was independent of the weight of the ground coat. In the fourth ring, the ground coat was so thin that it fired through. The results are tabulated in Table II.

TABLE II

| Dry weight ground coat/ring | Grams/sq. ft. | Grams of cover coat/ring | Force to open ring (gram weights) |
|---|---|---|---|
| 2.05 | 35.0 | 2.315 | 536.0 |
| 1.94 | 33.0 | 2.305 | 540.0 |
| 1.32 | 22.6 | 2.300 | 533.0 |
| 0.95 | 16.0 | 2.305 | 482.5 |

From these results, it would seem that the force exerted on the ring by the ground coat was symmetrical on the inside and outside and did not affect the results of the enamel being measured.

### VI. Procedure

When an enamel is to be tested, a slip, such as would be used for enameling, is prepared. The ground-coated ring to be used is weighed accurately, the enamel applied on the outside, dried, weighed, and fired at the usual temperature and time for the enamel. After firing, the lugs on the ring are ground off and the ring is ready for measuring its force.

The ring is placed in the apparatus and the load is applied until the ends just part. As this point is approached, a slight tapping of the apparatus will set the lower half of the ring in vibration. Until sufficient force is applied, the vibration can not take place. This does not occur as long as the lower end of the ring presses against the upper half. When the force is slightly in excess of that necessary, the ring will continue to vibrate for some time; if not quite enough force is used, the vibration will be very much damped and may not take place at all if the force is not nearly that required. This is an important point and helps considerably to determine accurately the weight required.

A strong light in back of the ring is also helpful to determine the point at which the ends of the ring part. It was found that in a series of measurements on the same ring, the results could be reproduced to within less than one gram, so that in most cases the error was well under 1%. When comparing different enamels, it is necessary to make only a single measurement on each enamel at a definite application. Since it is somewhat diffi-

cult to apply exactly three grams, it has been found expedient to use two rings, one slightly over and one slightly under three grams and to extrapolate between the two points.

## VII. Experimental

Most of the work to be described was done on a series of five enamels selected from those given by Andrews and Howe.[3] These were chosen to give a range of values for the coefficient of expansion. The compositions of the enamels, their softening temperature, and average coefficient of expansion are given in Table III. The values for the softening temperature and coefficients of expansion are those given by Andrews and Howe.*

TABLE III
COMPOSITION OF ENAMELS USED

| | *A* | *B* | *C* | *D* | *E* |
|---|---|---|---|---|---|
| Feldspar | 30 | 30 | 30 | 30 | 30 |
| Borax | 26 | 26 | 26 | 26 | 26 |
| Silica | 20 | 20 | 20 | 20 | 20 |
| Soda ash | 4 | 4 | 4 | 4 | 4 |
| Soda niter | 3 | 3 | 3 | 3 | 3 |
| Antimony oxide | 3 | 3 | 3 | 3 | 3 |
| Cryolite | | 5 | 14 | 8 | 2 |
| Fluorspar | 14 | 9 | | | 12 |
| Sodium silicofluoride | | | | 6 | |
| *Softening temp. (°F) | 1065 | 966 | 953 | 995 | 1026 |
| *Av. cu. coefficient $\times 10^{-7}$ (20°–475°) | 341 | 398 | 445 | 413 | 363 |

They are, respectively, enamels 12, 4, 1, 9, and 5 of Andrews and Howe. The enamels smelted in crucibles, using 5 pounds of raw batch per smelt, were milled with 6 parts of clay and 40 parts of water per 100 parts of enamel.

Table IV gives the results of the measurements on these enamels, the force required to open the rings being measured at 22°C.

It will be noted that the ground-coated rings did not weigh the same in every case. This variation is partly due to the differences in the weight of the steel, the metal applied in welding, and the weight of the ground coat. The first factor, *i.e.*, the weight of the steel, is the only one that affects the results. This was checked each time before the rings were formed from the strips and those deviating by more than 1% from the mean were rejected.

Figure 3 represents these results graphically. In every case the force on the ring for each enamel increases with the weight of application and, with few exceptions, the relationship is linear. That the force measured is an indication of the integral expansion is evident from Fig. 4, in which is plotted the force for a 3-gram application (taken

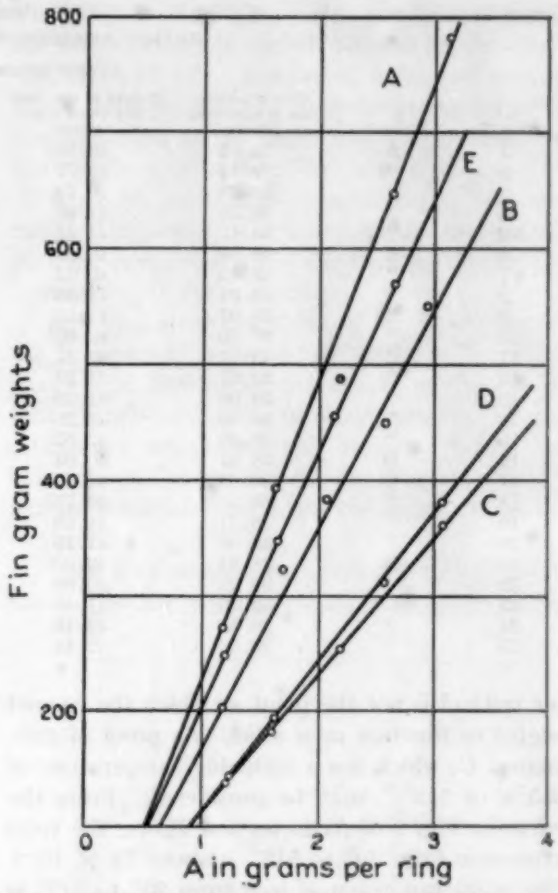


FIG. 3.—*F*, force in gram weight; *A*, application in grams per ring.

from Fig. 3) and the average expansion from 20° to 475° given by Andrews and Howe. With the exception of enamel D, the points fall about a straight line with small deviations. When it is remembered that the force measured depends to a great extent on the differential expansion of metal and enamel and to some extent on the modulus of elasticity, it can be easily understood why this relation is not more accurately linear. It might be inferred from this that enamel D must have a value for Young's modulus much lower than the other enamels in the series. Actual measurements of Young's modulus show this to be the case.

The softening point of the enamel is also a factor which determines the force on the ring since the differential contraction which causes the force may not take place until the enamel has become sufficiently viscous to resist the compression due to the change in length of the steel. The softening temperature as determined by the interferome-

TABLE IV
ENAMEL APPLICATION AND FORCE ON RING
(Force measured at 22°C)

| Ring No. | Enamel | Weight of ring and ground coat (grams) | Weight of ring and dry cover coat (grams) | Weight of dry cover coat ($A$) (grams) | $10^3 \times 1/A$ | Force $F$ (gram weight) | $10^3 \times 1/F$ |
|---|---|---|---|---|---|---|---|
| 1 | A | 38.92 | 40.105 | 1.185 | 844 | 272.6 | 366 |
| 2 | " | 39.14 | 40.77 | 1.63 | 613 | 394.8 | 253 |
| 3 | " | 38.59 | 40.78 | 2.19 | 457 | 487.4 | 205 |
| 4 | " | 39.34 | 41.99 | 2.65 | 377 | 645.3 | 155 |
| 5 | " | 38.17 | 41.31 | 3.14 | 318 | 781.1 | 128 |
| 6 | B | 38.86 | 40.03 | 1.17 | 855 | 204.6 | 488 |
| 7 | " | 38.45 | 40.13 | 1.68 | 595 | 321.7 | 311 |
| 8 | " | 39.31 | 41.38 | 2.07 | 483 | 383.7 | 260 |
| 9 | " | 39.07 | 41.65 | 2.58 | 388 | 449.8 | 222 |
| 10 | " | 37.70 | 40.65 | 2.95 | 339 | 547.2 | 183 |
| 11 | C | 39.17 | 40.37 | 1.20 | 833 | 139.0 | 719 |
| 12 | " | 39.67 | 41.24 | 1.59 | 629 | 182.5 | 546 |
| 13 | " | 39.08 | 41.29 | 2.21 | 452 | 251.9 | 397 |
| 14 | " | 39.60 | 42.26 | 2.66 | 376 | 278.5 | 358 |
| 15 | " | 39.48 | 42.57 | 3.09 | 324 | 361.1 | 277 |
| 16 | D | 38.81 | 40.04 | 1.23 | 813 | 143.1 | 699 |
| 17 | " | 38.66 | 40.335 | 1.675 | 597 | 191.9 | 521 |
| 18 | " | 38.58 | 40.755 | 2.175 | 460 | 252.9 | 395 |
| 19 | " | 38.71 | 41.29 | 2.58 | 388 | 311.5 | 321 |
| 20 | " | 38.08 | 41.15 | 3.07 | 326 | 380.7 | 262 |
| 21 | E | 38.81 | 40.00 | 1.19 | 840 | 248.5 | 402 |
| 22 | " | 39.23 | 40.88 | 1.65 | 606 | 345.5 | 289 |
| 23 | " | 39.33 | 41.46 | 2.13 | 469 | 456.5 | 219 |
| 24 | " | 39.53 | 42.19 | 2.66 | 376 | 568.7 | 176 |
| 25 | " | 39.56 | 42.44 | 2.88 | 347 | 898.1 | 111 |

ter method is not the point at which the enamel begins to function as a solid. As proof of this, enamel C, which has a softening temperature of 953°F or 512°C, may be considered. From the curve in Fig. 2 of Andrews and Howe, the total expansion from 20° to 512° is about $78 \times 10^{-4}$. The total expansion of iron from 20° to 512° is $70 \times 10^{-4}$. In that range, the enamel expanded more than the steel, and therefore the ring would tend to open rather than to close if the enamel solidified sharply at 512°. That it does not is to be expected from the general properties of glass.

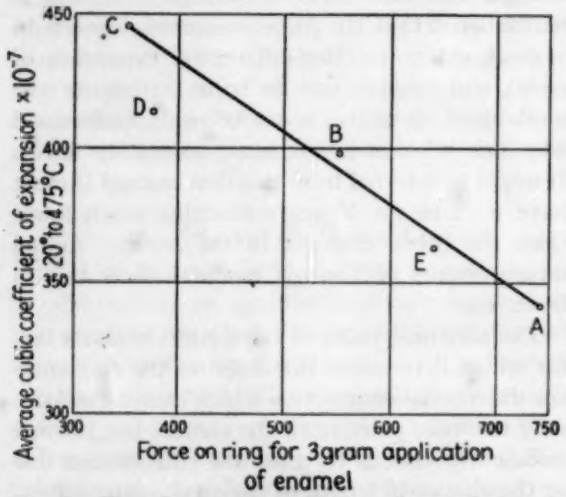


FIG. 4.—Force for 3-gram application of enamel plotted against the total expansion between 20° to 475°C.

If the softening temperature is no criterion, how can the data for the coefficient of expansion be used to calculate the stresses in the enamel? It is generally considered that glass is a supercooled liquid and that the change in physical properties with a change in temperature is due to a change in viscosity. Morey[4] considers this change in viscosity to be continuous, and it is therefore supposed that the enamel is constantly flowing under the stress of the steel. When the temperature is lowered, the viscosity increases so that the rate of flow becomes infinitesimal at some temperature below the softening point. Bair[5] has shown that there is no sharp change in the properties of lead glass at the so-called "softening temperature."

## VIII. Discussion

In a previous paper,[6] the compressive force in the enamel of an enameled piece of iron was shown to be

$$F = (\alpha_s - \alpha_e)\Delta T \frac{A_s E_s \times A_e E_e}{A_s E_s + A_e E_e}.$$

Where $\alpha_s$ and $\alpha_e$ = average coefficient of expansion of steel and enamel in the temperature interval ($\Delta T$) between the softening point of the enamel and room temperature.

$A_s$ and $A_e$ = cross-sectional areas of the steel and enamel, respectively.

$E_s$ and $E_e$ = Young's moduli of the two.

[4] G. W. Morey, "Constitution of Glass," *Jour. Amer. Ceram. Soc.*, 17 [11] 321–24 (1934).

[5] G. J. Bair, "Constitution of Lead Oxide-Silica Glasses: II, Correlation of Physical Properties with Atomic Arrangement," *ibid.*, 19 [12] 347–58 (1936).

[6] J. E. Rosenberg and A. Langerman, *loc. cit.*, p. 88.

It does not follow that this equation represents the force acting to close the ring, but it was postulated that the force is proportional to that internal stress. It was determined that the force measured is inversely proportional to the diameter ($d$) of the ring so that the equation for the force may be written

$$F \propto \frac{(\alpha_s - \alpha_e)\Delta T}{d} \cdot \frac{A_s E_s \times A_e E_e}{A_s E_s + A_e E_e}.$$

It seems that the coefficient-of-expansion data can not give useful results because we do not know in what range of temperature to consider the enamel acting as a solid. The ring method, however, gives directly a measure of the stress to which the enamel is subjected, and the results of these measurements may be used to obtain a constant characteristic of the enamel. For any given enamel on rings of the same steel, the force will vary with the thickness of the enamel. This equation with the two variables, $F$ and $A_e$, is not linear, but can be reduced to linear form by inverting as follows:

$$\frac{1}{F} \propto \frac{d}{(\alpha_s - \alpha_e)\Delta T} \cdot \frac{A_s E_s + A_e E_e}{A_s E_s \times A_e E_e}$$

$$\frac{1}{F} \propto \frac{d}{(\alpha_s - \alpha_e)\Delta T} \cdot \left(\frac{1}{A_s E_s}\right) + \frac{d}{(\alpha_s - \alpha_e)\Delta T} \frac{1}{A_e E_e}$$

Where $1/F = y$.
$1/A_e = X$.

If the proportionality factor is removed by introducing $k$, we may write

$$y = k\left(\frac{d}{\alpha_s - \alpha_e)\Delta T} \cdot \frac{1}{E_e} X + \frac{d}{(\alpha_s - \alpha_e)\Delta T} \cdot \frac{1}{A_s E_s}\right).$$

If $1/F$ is plotted against $1/A_e$ for a given enamel, the curve comes out a straight line and is the form

$$y = mx + b.$$

Where $m$ = slope of line and is equal to

$$\frac{kd}{(\alpha_s - \alpha_e)\Delta T} \cdot \frac{1}{E_e}$$

Since $kd$ are both constants associated with the ring and not with the enamel, it is seen that the slopes of the lines for different enamels are proportional to

$$\frac{1}{(\alpha_s - \alpha_e)\Delta T E_e}.$$

The reciprocal of the slope is

$$(\alpha_s - \alpha_e)\Delta T E_e.$$

### (1) Thermoelastic Constant

This might be called the thermoelastic constant ($TE$) of the enamel on steel. There is, of course, the difficulty cited above that the rate at which the fired enamel is cooled determines the effective value of $\Delta T$. In general, firing and cooling in the open air will give sufficiently reproducible results and it is the most practical method for laboratory conditions. The absolute value of $TE$ can be calculated approximately, but the exact value awaits a solution of the mechanical problem as to the value of $k$ in the equation for the force acting to close the ring.

$(\alpha_s - \alpha_e)$ is of the order of $10^{-6}$ per degree; $\Delta T$ is probably between 400° and 500°C. $E_e$ is about $5 \times 10^{11}$ dynes per square centimeter so that $TE$ is between 1 to $10 \times 10^9$ dynes per square centimeter for commercial enamel. When the value of $k$ in the equation for the force is known, it will be possible to calculate the value of $TE$ directly.

Figure 5 shows the data for the enamels plotting the reciprocals of $F$ against $A_e$. $C$ and $D$ are so close to each other that only one of them is shown on the graph.

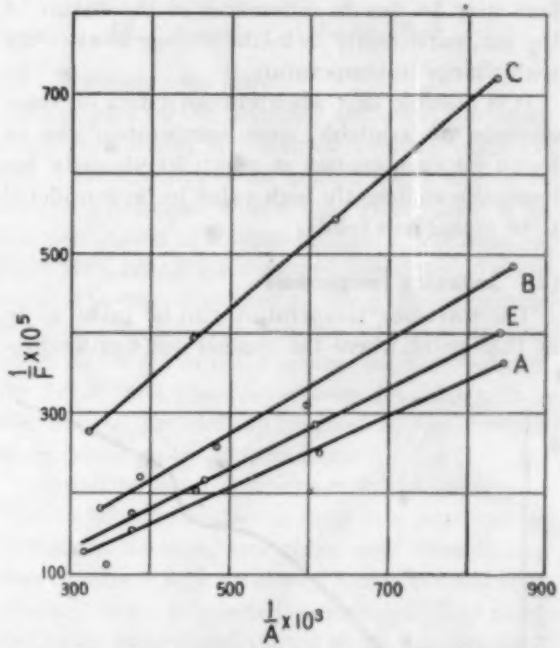


FIG. 5.—Reciprocals of force ($1/F$) plotted against reciprocal of application ($1/A$); data are the same as that used in Fig. 3.

Table V shows a comparison of the slope of the curves for the five enamels with the average cubic expansion between 20° and 475°, as well as the force on the ring for a 3-gram application.

It is remarkable that the slope of the curve is

directly proportional to the force on the ring. If, for example, the force on the ring is divided by the numerical value of the slope, a constant is obtained which differs but little for the five enamels. This might be interpreted to confirm the suggestion that the thermoelastic constants cover all the factors which affect the force that the enamel produces on the ring.

It is, of course, simpler to determine the force for a 3-gram application than it is to run a series of applications and determine the slope of the curve as was done. The slight differences noted

TABLE V

| | (I) Av. cu. coefficient $\times 10^{-7}$ (20–475°C) | (II) Reciprocal of slope of $1/F$–$1/A$ curve $\times k(TE)$ | (III) Force on ring for 3 g. enamel | (IV) Ratios of III/II $\times 10^3$ |
|---|---|---|---|---|
| A | 341 | 2.22 | 740 | 3.3 |
| E | 363 | 1.89 | 645 | 3.4 |
| B | 398 | 1.69 | 550 | 3.2 |
| D | 413 | 1.19 | 375 | 3.1 |
| C | 445 | 1.16 | 350 | 3.0 |

here may be due to differences in the nature of the frit, particularly as to the change in viscosity with change in temperature.

It is possible that when viscosity data on these enamels are available, some temperature can be found for each enamel at which its viscosity has reached a sufficiently high value to be considered to be acting as a solid.

### (2) Softening Temperature

The softening temperature can be taken to be at that point where the enamel quits expanding.

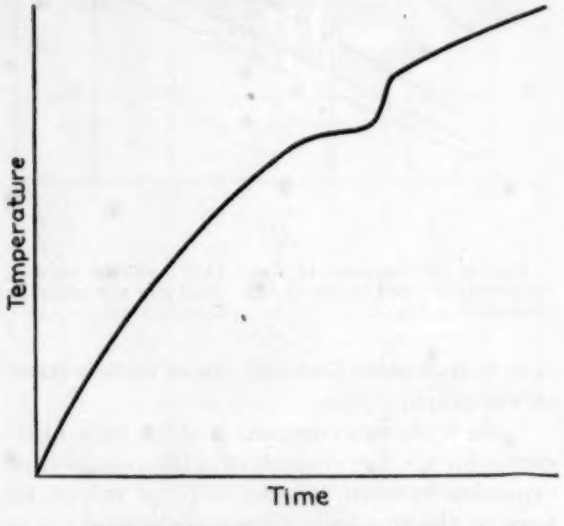


FIG. 6.—Heating curve for vitreous enamel showing heat absorption below softening point.

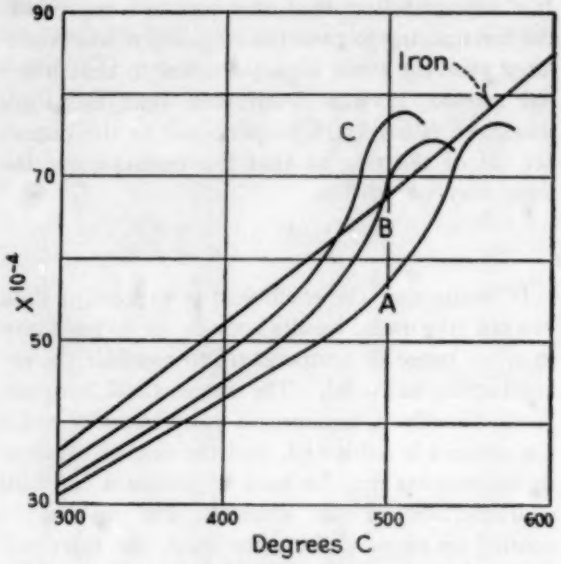


FIG. 7.—Portion of integral expansion curves for iron and three enamels.

The results obtained by this method, particularly on enamel 1 of Andrews and Howe, indicates that this temperature is too high, since at this temperature, the expansion of the enamel exceeds that of the iron. Harrison and Sweo[6] have studied the heat absorption by enamels when heated at a constant rate. They noted that at a certain point the temperature of the glass did not increase at the usual rate, but was considerably less. For a certain interval, as shown in Fig. 6, the temperature did not increase, but after this range was passed, the temperature again increased in the normal manner. They compared the point of maximum heat absorption with the softening point as determined by the interferometer, the cone, and other methods. Examination of some of the data shows that the softening point as determined by this means is about 30° lower than that obtained by the interferometer method which gives the lowest results of the other methods cited.

Harrison and Sweo consider that this point might correspond to a structural change in the glass. From the graph (Fig. 6), it is noted that these changes began to take place at a temperature lower than that of the maximum heat absorption, and this point is approximately 30° lower than the point of maximum absorption.

[6] W. N. Harrison and B. J. Sweo, "Fusion Properties of Ground Enamels as Influenced by Composition," *Bur. Stand. Jour. Research*, **10** [2] 189–209 (1933); R. P. 524; *Ceram. Abs.*, **12** [5] 181 (1933).

This would mean that the softening temperature may be 60° lower than the values given by Harrison and Sweo. While these are merely assumptions, in one case at least it seems to account for the anomalous results in the case of enamel No. 1 of Andrews and Howe, and in enamel C in this study.

Figure 7 shows a portion of the interferometer expansion curve for the three enamels, A, B, and C, as well as the expansion curve for iron in the same temperature range. If the softening point is the point where the expansion becomes zero, then only enamel A would show any stress on the ring. Actually, even C shows that it contracted less on cooling than did the iron in the same temperature interval. Consequently, the softening point of any enamel that shows a force tending to close the ring must be less than the point where the integral-expansion curves of iron and the enamel cross. For enamel C, it is below 470°C and for B below 495°C.

The force on the ring is proportional to the difference in the integral expansion, and therefore the distances between these graphs for steel and enamel would give an excellent indication of the force if the softening point were exactly known.

If some change is taking place in the enamel, then it should be possible to see the results of that change by studying carefully the curve obtained by the interferometer expansion. The slope of the interferometer curve was measured and plotted against temperature, showing that the change in slope of the curve is more or less sharp at about 425°, corresponding to the beginning of heat absorption by the method used by Harrison and Sweo. It is difficult to make accurate measurements on the graph as printed in the published papers, but with an accurate plot and original data it might be possible to get valuable information on the softening temperature.

The slope of the curve can be readily determined with a tangent meter. The slope of the curve is of course the coefficient of expansion at the particular temperature measured and a radical change in this value must accompany some internal structural change.

It is impossible at present to obtain accurate values for $\alpha_s$, but the value of $\alpha_e$ is important only in the effect of producing a strain in the enamel, and there is not much point to determine an indirect figure when the direct result can be measured.

### (3) Other Metals

To test to some extent the validity of the equation, these same enamels were applied to copper rings of approximately the same dimensions. The force for an application of approximately 2.3 grams is shown in Table VI. These enamels were applied directly on the copper metal and some of the irregularities noted are probably due to this fact.

TABLE VI

| | Force on copper rings | |
|---|---|---|
| Enamels | Weight of enamel/ring (grams) | Force to open ring (gram weight) |
| A | 2.28 | 273 |
| B | 2.38 | 260 |
| C | 2.3 | 110 |
| D | 2.29 | 36.7 |
| E | 2.04 | 324.4 |

While the magnitude of the forces is not exactly the same, the order is approximately that obtained for steel rings.

## IX. Accuracy of the Method

### (1) Effect of Firing Time

Some idea of the accuracy and reproducibility of the results may be obtained from the following test. Three rings were coated with the same amount of enamel within 0.01 gram, 2.42, 2.43, and 2.43 grams of enamel E; No. 1 was fired for 2 minutes, No. 2 for 3 minutes, and No. 3 for 4 minutes to determine how accurate the firing must be to get reproducible results. The two-minute fire gave a force of 516.8 grams, the three-minute fire 517.8, and the four-minute fire 523 grams. The normal fire for an enamel in the furnace being used is about $2^1/_2$ minutes.

In order to test the difference in the strain produced when the enamel is fired in a box-type or continuous furnace, two rings were chosen, the force of which was measured under normal conditions of firing in a box-type furnace. The rings were again welded and placed in the furnace at a temperature of 1400° and allowed to cool gradually overnight. The results are of interest, particularly since they are different for two enamels. Enamel B, before annealing, gave a force of 433.6; after annealing 427.5, a decrease of 6 grams. Enamel C, before annealing, gave a force of 268; after annealing a force of 296, an increase of 28 grams. This cooling, of course, is much longer than could possibly be obtained in a continuous furnace, and even under these condi-

tions the change in the force is not very great. The data cited are not meant to give an accurate estimate of the effect of slow cooling because some distortion may have taken place on rewelding the ring. It merely indicates that the effect is not marked.

### (2) Effect of Quick Cooling

Quenching these enamels was tried to see the effect on the force. The rings were measured, welded, and then placed in the furnace and brought to the original firing temperature, 1520°, in about 2 minutes. The rings were taken from the furnace and dropped directly into oil. For enamel B, the force before quenching was 437, after quenching, 592; for enamel C before quenching, 278.7, after quenching, 380. The increase in this case is remarkable, and it is particularly interesting that the percentage increase in force for both enamels is approximately the same: for enamel B, 35½%, and for enamel C, 36%. The fact that the increase is the same in both cases might indicate that the change of force is due to the change taking place in the steel, but the metal is not known to change its value either for Young's modulus or coefficient of expansion.

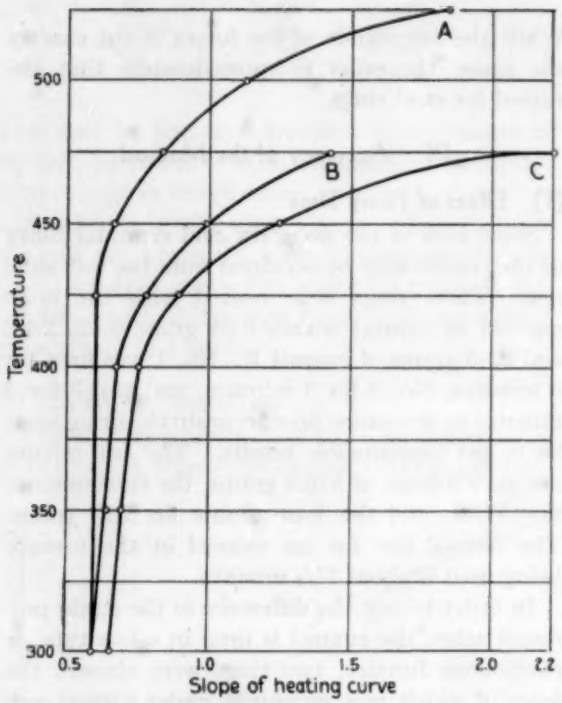


FIG. 8.—Plot showing change of coefficient of expansion with change in temperature.

### (3) Effect of Temperature

The equation for the force postulates a variation in the force with the temperature at which the force on the ring is measured. The softening temperature is fixed by the property of the enamel, but the enamel is measured at a temperature which may be varied.

The following data were obtained on ring No. 39.

| Temperature (°C) | Force to open ring (gram weight) |
|---|---|
| 25 | 439.70 |
| 16 | 443.50 |
| − 6 | 460.61 |
| −11 | 475.00 |

The force diminishes as the temperature of the measurement increases, and it seems that a point will be reached when the force will be zero. At this point, the integral expansion of the enamel and the steel will be equal.

### (4) Effect of Time

Two rings were measured, which originally had a force of about 450 grams, and one month later showed a decrease of 13 and 9 grams, respectively. This was for enamel B. Similarly for enamel C: two rings, having a force of about 270 grams, showed a decrease of about 9 and 12 grams, respectively.

## X. Summary

(1) A simple and accurate means of studying the integrated effects of the various factors which produce stresses in enamel fired on metal is presented.

(2) This accuracy of the results is indicated by the agreement with values for the coefficient of expansion determined by the interferometer method.

(3) A constant is introduced whose value gives a direct measure of the stress to which enamel on steel is subjected. This constant is called the thermoelastic constant (*TE*).

(4) Where the differences in softening point and Young's modulus are slight, comparative values are obtained for the integrated expansion of the enamel in the range in which it acts as a solid.

(5) Data are presented which indicate that the softening point of an enamel as determined by the interferometer method is considerably higher than the temperature at which it effectively acts as a solid.

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# SOME STUDIES ON REACTIONS BETWEEN GLASSES AND PHOSPHATE SOLUTIONS*

By J. B. Brown † and Arthur S. Watts ‡

Abstract

A technique is described for determining the durability of glass exposed to phosphate solutions. Inactivation of solutions exposed to glass is reported on the basis of time and temperature and is accompanied by solution (or peptization) of certain glass constituents, especially sodium, magnesium, and silicon. Small additions of sodium-silicate to phosphate solutions cause inactivation. If water is heated with powdered glass, any phosphate solution in which it is used will be inactive. One explanation for these phenomena is suggested.

## I. Introduction

In an investigation being conducted in the field of ceramics in dentistry, the writers have observed that certain relatively weak phosphate solutions, which were at first decidedly corrosive to certain experimental glasses, became inactivated after exposure to glass for varying periods. The inactivation was not accompanied by an appreciable change in the $p_H$ of the phosphate solution.

In the course of the work, it was necessary to test experimental glass surfaces, designed for use in the human mouth, for their resistance to saliva. In this connection a solution of inorganic salts, approximating the mineral composition of a normal human saliva at ten times normal strength (designated S–4) was made up as follows:

| | Grams |
|---|---|
| $KH_2PO_4$ | 2.46 |
| $K_2HPO_4$ | 7.69 |
| NaCl | 5.30 |
| KCl | 9.30 |

Distilled water to one liter.

The $p_H$ of this solution is about 7.2. Certain of the minor mineral constituents ordinarily found in saliva have been necessarily omitted. As a result of a long series of experiments on natural and artificial salivas, however, it was found that the phosphates contained therein are the most important components as far as the corrosive effect of the saliva on glass is concerned.

Briefly, the method of testing resistance of a glass to etching is as follows:

Seventy-five cubic centimeters of S–4 is introduced into a 125-cubic centimeter Pyrex-brand Erlenmeyer flask. The experimental glass, fused on to small porcelain slabs, about 0.5 by 1.0 centimeter in size, is placed in this solution. The flask is covered with a small glass Petri dish and heated for two days at 80°C in a constant-temperature water bath. At the end of the test period the slab is washed with hot water, dried, and vigorously rubbed with a cloth. The glass surface is examined by reflected light under a binocular microscope of 75 ×. For lack of quantitative evaluation of etching, it is described qualitatively. Etching up to $2^+$ is detectable only under the microscope. Above $2^+$, the glass surface is macroscopically dull. In some of the tests with lesser resistant glasses, this may proceed to $5^+$ when the glass becomes pearly or even chalky in appearance.

A significant feature of the experiments, reported here, is the use of higher than body temperatures. The use of such a test temperature was designed, first, to shorten the time of test and, second, to provide a test temperature which would maintain a sterile condition. Many of the phenomena hereafter reported would not be observable at body or laboratory temperature except over periods of months or years because the temperature coefficient of the etching reaction is very high.

Another point that should be emphasized is the effect of a definite firing and tempering technique on the durability of a glass surface. The resistance test used is decidedly different from the numerous glass powder tests which have been described in the literature.[1]

## II. Experimental Part

The reported experiments have been selected from a large number which have been carried out during the past two years.

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‡ Department of Ceramic Engineering, Ohio State University.

[1] An excellent review and a comprehensive bibliography of the subject of durability of glasses have been given by J. W. Mellor, *Trans.* [Eng.] *Ceram. Soc.*, **34** [2] 113–90 (1934–35); *Ceram. Abs.*, **14** [9] 233 (1935).

### (1) Comparison of Activity of Fresh and Old Specimens of S–4

A specimen of S–4 was stored for three months in an ordinary cork-stoppered bottle at laboratory temperature. At the time of the test, a fresh specimen was prepared. The $p_H$ of the S–4 solutions, determined colorimetrically, was not appreciably different. Seventy-five cubic centimeter portions of the two solutions were placed in Pyrex-brand flasks with six test slabs, fired with "G" glass, which is a semiresistant glass. After two days at 80°C, they were examined with the following results:

| S–4 | |
|---|---|
| Old | Fresh |
| – | 4 + dull |
| – | 4 + dull |
| – | 3 + dull |
| – | 3 + dull |
| – | ± |
| – | – |

It is obvious that the old solution was completely inactivated by standing in a glass bottle; the fresh solution strongly etched four of the six slabs.

The results with the fresh solution show a wide range in resistance. This is one of the reasons for using several test specimens and is a common experience in this work and in ceramic material in general. The writers have been unable to devise firing conditions which will produce glazed surfaces of uniform resistance under the conditions of this test. The slabs used in this work were fired under rigidly controlled conditions in lots of fifty to one hundred in a pyrometer-controlled muffle furnace at 962°C, a temperature considerably above the liquefaction point of the glass; further, they were allowed to cool in the closed furnace for thirty minutes, the temperature falling to 762°C. They were then removed from the furnace and allowed to cool rapidly to room temperature.

### (2) Effect of Heating S–4 in Pyrex-Brand Glass

At first it was thought that this inactivation might be explained as due to the effect of traces of carbon dioxide. It seemed possible that a solution on long standing might lose (or gain) traces of this gas which might markedly affect the etching reaction. A 250-cubic centimeter specimen of freshly prepared S–4 was boiled for thirty minutes in a 500-cubic centimeter Pyrex-brand flask; it was then diluted back to volume with untreated boiled distilled water. The S–4 thus treated was less reactive than fresh S–4, but it had not been completely inactivated as described previously. Furthermore, the addition of traces of sodium bicarbonate did not restore the activity. From these results it seemed that the presence or absence of traces of carbon dioxide could not account for the inactivation. It was equally evident that boiling the solution in Pyrex-brand glass for thirty minutes resulted in some definite change in the solution.

### (3) Comparison of Activity of S–4 with That of a Solution of Phosphates and Inactivation of Both Solutions by Heating in Pyrex-Brand Glass

A solution of primary and secondary potassium phosphates was made up, the concentration of these salts being the same as in S–4. Specimens of these (75 cc.) were tested with slabs of "G" glass by the usual procedure. Additional specimens of these solutions were also heated in covered Pyrex-brand flasks for six days at 80°C and then tested for activity. The following results were obtained:

| S–4 untreated | S–4 80°C for six days | Phosphates untreated | Phosphates 80°C for six days |
|---|---|---|---|
| 3 + D* | – | 3 + D | + S |
| 2 + S† | – | 3 + D | ± |
| + S | – | ± | – |
| – | – | ± S | – |

* D = dull. †S = etched in spots.

These results, which agree within the limit of what is considered the experimental error, show definitely equal activity of S–4 and the phosphate solution and almost complete inactivation of both solutions by heating in Pyrex-brand glass for the time specified.

From these experiments and many others, it became increasingly apparent that some reaction was occurring between the Pyrex-brand glass container and the test solution. This reaction was very slow at room temperature in ordinary glass; it was much more rapid at higher temperatures even in Pyrex-brand glass. At this point, the procedure was adopted of storing all of the S–4 solutions in paraffin-coated containers, which were subsequently shown to preserve the activity of the solution indefinitely.

### (4) Rate of Inactivation of S–4 by Glass Powders at 80°C

The glasses used in this experiment were Pyrex-brand, ordinary bottle glass, and "X" glass, all pulverized to pass 200-mesh. "X" glass is a non-

resistant experimental glass. Seventy-five cubic centimeters of S–4 were treated in a 125-cubic centimeter Pyrex-brand flask with 0.75 gram of the glass powder at 80°C for the time noted. The solution was filtered and subjected to the standard test with four slabs, coated this time with "X" glass. It is to be noted here that all of these tests have introduced unavoidably the effect of the Pyrex-brand flask on the test solution. The results follow.

| Time of treatment at 80°C (hr.) | Pyrex-brand glass | "X" glass | Ordinary glass |
|---|---|---|---|
| 0 | 4 + D* | | |
| | 4 + D | Same | Same |
| | 4 + D | | |
| | 3 + D | | |
| 1 | 3 + D | 3 + D | 2 + |
| | 3 + D | 3 + D | + |
| | 3 + D | 3 + D | + |
| | 3 + D | 2 + | + |
| 4 | 3 + D | 3 + D | − |
| | 3 + D | 3 + D | − |
| | 3 + D | 3 + D | − |
| | 3 + D | 2 + | − |
| 8 | 3 + D | 3 + D | − |
| | 2 + | 2 + | − |
| | 2 + | 2 + | − |
| | 2 + | 2 + | − |
| 15 | + | − | − |
| | + | − | − |
| | + | − | − |
| | − | − | − |
| 24 | All − | All − | All − |

* D = dull.

These results show that Pyrex-brand powder has inactivated S–4 in 24 hours, "X" glass in 15 hours, and ordinary glass in less than 4 hours. These tests are the more convincing in that the test slabs were coated with "X" glass which in the experience of the writers has always etched easily at 80°C.

### (5) Chemical Changes in a Primary-Secondary Potassium Phosphate Solution as a Result of Reaction with Glass Powder at 80°C

From the previous results, it was becoming increasingly apparent that the phosphate solutions were becoming inactivated as a result of passage of certain constituents of the glass surface or the glass powders into solution. While such action between water and glass has been known for a long time, especially in the case of the powders, the inactivation phenomenon, as far as the writers are aware, is novel. To study the changes in phosphate solutions during inactivation, it was decided to inactivate a simple mixture of pure primary and secondary potassium phosphates and to determine chemical change in the solution spectrographically. The phosphate solution, containing 2.46 grams of $KH_2PO_4$ and 7.69 grams of $K_2HPO_4$ in one liter, was employed in place of S–4 because changes would be more easily detected in the simpler solution. The solution was kept in paraffin-coated bottles. Part of it, *a*, was immediately subjected to spectrographic analysis.[2] Two specimens (75 cc.) were heated with 0.75 gram of "X" powder in large nickel crucibles for 15 hours at 80°C. They were united and filtered. The resultant solution, *b*, was shown to be inactive by test. The remainder of *b* was subjected to analysis. A third specimen (200 cc.) was heated with 2.0 grams of "X" powder in a 250-cubic centimeter Pyrex-brand Erlenmeyer flask for 15 hours at 80° C. Part of this solution was used for test and was shown to be inactive. The remainder was analyzed. The results of these analyses showed definitely a solution of sodium, magnesium, and silicon, concurrent with inactivation. There was no detectable increase in calcium and no increase in potassium, which is not unexpected because of its high concentration in the solution at the start. Colorimetric analysis of the original and of the inactivated solutions showed no detectable difference in phosphate concentrations. These results appear to indicate, therefore, an appreciable solubility of certain constituents of "X" glass in the phosphate solution; these constituents would seem to be silicates of sodium and magnesium (and potassium). This confirms previous work, except in the case of magnesium.

### (6) Inactivation of S–4 by Sodium Silicate

If, as indicated above, phosphate solutions are inactivated by exposure to glass because certain silicates dissolve, then the S–4 solution should be inactivated by adding sodium silicate. In the following experiment, varying amounts of sodium silicate ($Na_2SiO_3$) were added to 75 cubic centimeters of the S–4 solution as indicated in the table and the resultant solution was tested with four slabs, coated with "X" glass, for two days at 80°C with the following results:

| $Na_2SiO_3$ added (grams) | | | | | | |
|---|---|---|---|---|---|---|
| 0.0 | 0.01 | 0.03 | 0.05 | 0.1 | 0.2 | 0.5 |
| ++++ D* | +++ D | ± | − | − | − | − |
| ++++ D | +++ D | ± | − | − | − | − |
| ++++ D | +++ D | − | − | − | − | − |
| ++++ D | +++ D | − | − | − | − | − |

* D = dull.

[2] The writers are indebted to Ruth Jones for these determinations and to Wallace R. Brode of the Chemistry Department for the use of his apparatus.

From these data, it is obvious that a concentration of three parts of sodium silicate in 7500 parts of solution results in complete inactivation of S–4.

### (7) Effect of Concentration of S–4 on Its Inactivation by Sodium Silicate

The S–4 solution was made up originally to represent an approximation of the important saline constituents of normal saliva at ten times normal strength. When the work was repeated in the preceding experiment with S–4 diluted ten times and with a specimen of normal saliva, the writers failed to get complete inactivation by adding sodium silicate, even in large amounts. In the following tests, therefore, the effect of concentration of S–4 on its inactivation with sodium silicate was studied. To 75 cubic centimeters of specimens of S–4 diluted as noted below was added 0.03 gram of sodium silicate. The solutions were tested with "X" slabs as before for two days at 80° C.

| Concentration of S–4 | | | | |
|---|---|---|---|---|
| S–4 1.0 | S–4 0.8 | S–4 0.5 | S–4 0.2 | S–4 0.1 |
| – | – | – | +++ D* | +++ D |
| – | – | – | +++ D | +++ D |
| – | – | – | + | +++ D |
| – | – | – | – | ++ |

* D = dull.

In the higher concentrations, inactivation was complete; in the lower two, comparatively little inactivation has resulted because the dilution effect amounts to about the effect observed.

It occurred to the writers that failure to inactivate diluted S–4 may have been due to the fact that the buffer effect of the phosphates was so diminished by dilution that the solution assumed the high $p_H$ of the added silicate. Accordingly, the effect of neutralized silicate was tried. To a solution of sodium silicate, enough hydrochloric acid was added to bring the $p_H$ to 7.2; the resulting solution was diluted to a concentration of one gram per 100 cubic centimeters (based on original silicate). This solution, then, contained a mixture of sodium silicate and colloidal silicic acid (with sodium chloride resulting from the neutralization). Varying amounts of this solution were added to 75 cubic centimeters of S–4 as indicated in the table below and tested for activity as before.

Neutralized silicate was slightly less effective than sodium silicate on S–4, five parts in 7500, completely inactivating; on the other hand, it was more effective on diluted S–4, almost inactivating in a concentration of one part in 7500. The writers hope to study further the kinetics of this reaction.

### (8) Reactivation of Inactivated S–4 by Dilution

Since inactivation of S–4 by exposure to glass is due to solution and perhaps to saturation with some of the components of the glass, dilution of the inactivated solution with water should partially restore the activity, the diluted solution not being saturated with the components in question. Two hundred cubic centimeters of S–4 was treated with two grams of "X" powder at 80° for 15 hours. The solution was filtered and found upon test to be inactive. Dilution of this inactive solution to one-half and one-tenth strength with distilled water definitely but not completely restored the original activity.

### (9) Preparation of Inactive S–4 Solutions from Water Previously Exposed to Glass Powder

At this point, it seemed that the phosphate solution used in these tests was simply accelerating the reactions between glass and water which are known to occur when glass is exposed to water alone. In common experience, this reaction does not occur in ordinary glassware to a noticeable extent; distilled water is not appreciably corrosive, but such a reaction is known to occur if a glass powder with its large surface is exposed to distilled water at temperatures near the boiling point. In the following experiment, 700 cubic centimeters of distilled water were heated with 3.5 grams of "X" powder at 95° to 100°C for five days. At the end of this time the water was filtered. Analysis of the water for dissolved solids showed 0.38 gram per liter. The $p_H$ of the resulting solution was above 9.5. S–4 solution was made up from this water, containing dissolved glass (designated S–4 (G)). The activity of this solution was compared with S–4 prepared in the usual way. The standard test was applied, using

| S–4 | | | | S–4 (diluted with 9 vol. water) | | | |
|---|---|---|---|---|---|---|---|
| Neutral silicate added | | | | | | | |
| 0.0 | 1.0 | 3.0 | 5.0 | 0.0 | 1.0 | 3.0 | 5.0 |
| ++++ D | ++++ D | ++++ D | – | ++++ D | – | – | – |
| ++++ D | ++++ D | ++++ D | – | +++ D | ± | – | – |
| ++++ D | ++++ D | +++ D | – | +++ D | ± | – | – |
| ++++ D | ++++ D | +++ D | – | +++ D | + | – | – |

slabs coated with "X" and "G" glasses. The following results were obtained:

| "X" slabs | | "G" slabs | |
|---|---|---|---|
| S-4 | S-4(G) | S-4 | S-4(G) |
| 4 + D* | + I† | 3 + D | − |
| 4 + D | + I | 3 + D | − |
| 4 + D | + I | 3 + D | − |
| 4 + D | + I | + | − |

* D = dull.
† I = etching accompanied by iridescence.

It is evident that S-4 (G) is almost inactive to "X" glass and completely inactive to "G" glass. Water, treated with glass powder under the conditions stated, contains enough dissolved (or finely suspended) glass to inactivate a phosphate solution made up from this water.

### (10) Rate of Solution (or Peptization) of Glass Powders by Distilled Water

The glasses used in this experiment were Pyrex-brand, ordinary tumbler glass, pure silica, "X" glass, and "F" glass. "F" glass is one of the borosilicate glasses which in the standard test is much more resistant than "X." These were pulverized to pass 150-mesh ("X" glass to 200-mesh). The glass powder (7.0 grams) was placed in a R.B. Pyrex-brand flask with 1400 cubic centimeters of distilled water. This was fitted with a Pyrex-brand reflux condenser and placed on a boiling water bath. The water was not stirred, natural convection currents being considered sufficient for this purpose. At one, three, and five days, the flask was shaken, the contents were allowed to settle for an hour, and the specimens were removed for analysis. The one-day specimens were filtered through quantitative paper (C.S. and S. black) and 50-cubic centimeter aliquots were evaporated to constant weight in platinum dishes for solid determination. The three- and five-day specimens were centrifuged at high speed, the liquid filtered as before and analyzed. The data follow.

Solubility of Various Powdered Glasses in Distilled Water at 95–100°C

| Time (days) | Glass (grams/liter) | | | | |
|---|---|---|---|---|---|
| | Pyrex brand | Tumbler | $SiO_2$ | "X" | "F" |
| 1 | 0.248* | 0.712* | 0.264* | 0.288 | 0.146 |
| 3 | 0.054 | 0.892 | 0.010 | 0.352 | 0.250 |
| 5 | 0.104 | 0.888 | 0.028 | 0.334 | 0.320 |

* Filtered only.

While the results on tumbler glass merely verify numerous previous results on glass powders of this type, the comparative data with the other glasses noted are of interest. The "X" and "F" glasses, by this test, are decidedly more resistant than tumbler glass, a lime-silicate glass; they are somewhat more soluble than Pyrex-brand, a glass noted for its durability. It was surprising, however, to note an appreciable solubility (or peptization) of powdered silica under the conditions of the experiment. Furthermore, these solubility data on "X" and "F" glasses are not significantly different except for the somewhat slower solution of "F." This is surprising because "F" is decidedly more resistant than "X" to etching by phosphate solutions when glass surfaces prepared by a given firing technique are employed.

S-4 (G) solutions were prepared from these same glass solutions and were tested for activity by the usual procedure at 80°C with slabs of "G" and "X" glasses with the results shown in the table on following page.

Practically complete inactivation has resulted except in the case of silica; even with silica demonstrable loss in activity was shown with "G" slabs.

## III. Discussion of Results

In the preceding work, a curious inactivation of dilute phosphate solutions by exposure to glass has been demonstrated. These solutions which, when freshly prepared, are markedly corrosive to glass surfaces at 80°C become inactive when they have been stored for some months in ordinary glass bottles or when they have been heated in a Pyrex-brand container for a few days. The inactivation is a matter of a few hours when the solutions are heated with glass powders at 80°C. Concurrent with inactivation, soluble silicates (or highly dispersed glass) appear in the phosphate solution. Furthermore, if various glass powders are heated with distilled water for some days, soluble silicates (or finely dispersed glass) pass into the water phase to an extent depending on the kind of glass used. When these resulting solutions are used instead of distilled water in preparing S-4 solutions, they are not corrosive to glass surfaces.

The following possible explanation of these phenomena is presented. All glass surfaces react slowly with water, either by actual solution or as a result of hydrolysis and concurrent solution of certain alkali silicates. This reaction may be extremely slow with surfaces of glass, resulting from fusion rather than from fracture. The reaction is rapid with pulverized glass and is dependent in part at least on the composition of the glass.

Phosphates accelerate this reaction, giving the typical etching effect of the S–4 solution on glasses like "X" and "G" in a few hours at 80°C, an effect not observed, however, when these glasses are heated with boiling water alone for weeks. Exposure of a phosphate solution to glass for some time previous to its use in a test, the time depending on the experimental condition, brings about a solution of certain silicates which results in saturation of the solution with glass (with the products of the reaction) and therefore retards any further action of this solution on glass or, in effect, inactivates the solution. This explanation is confirmed by the fact that the solution can be inactivated by adding very small amounts of sodium silicate.

| S–4 | | S–4(G) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Tumbler | | Pyrex brand | | "X" | | $SiO_2$ | |
| Slabs of "X" | "G" | "X" | "G" | "X" | "G" | "X" | "G" | "X" | "G" |
| 4 + D* | 3 + D | + | − | − | − | + | − | 4 + D | 2 + |
| 4 + D | 3 + D | − | − | − | − | − | − | 4 + D | + |
| 4 + D | 2 + | − | − | − | − | − | − | 3 + D | + |
| 3 + D | − | − | − | − | − | − | − | 3 + D | − |

* D = dull.

Another point which seems worthy of notice in the above data is concerned with the lack of correlation between the durability of glasses "X" and "F" and the glass powder and S–4 durability tests described above. In the experience of the writers, these two glasses respond quite differently to the S–4 treatment at 80°C, "X" glass being easily attacked and "F" quite resistant. The solubility of these glasses as powders in water is almost the same at the end of five days at 95 to 100°. These facts seem to indicate that the two glasses as powders react the same, but react differently as freshly fused surfaces. We are inclined to the belief, then, that the two tests present essentially different aspects of durability and that the surface resulting from a given annealing technique may exhibit a resistance to attack quite different from a surface resulting from fracture. This is borne out further by the fact that minor differences in annealing technique result in marked alteration in the durability of the resultant surface.

## IV. Summary

(1) A technique for determining the durability of glass when exposed to phosphate solutions is described.

(2) Phosphate solutions, which are corrosive to glass, become inactive when they are stored in glass for some months or when they are heated in glass for some hours.

(3) The inactivation is accompanied by solution (or peptization) of certain constituents of the glass, especially sodium, magnesium, and silicon (and potassium).

(4) Addition of small amounts of sodium silicate to phosphate solutions causes inactivation.

(5) If water is heated with glass powder, and a phosphate solution made up from this water, the resultant solution is inactive.

(6) An explanation for these phenomena is suggested.

# CERAMIC ABSTRACTS

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## AMERICAN CERAMIC SOCIETY

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The bold-face number following the journal name is the volume; the issue number is in brackets, followed by the page numbers, then the year in parentheses.

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July, 1937

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### Abrasives

**Abrasives.** V. L. Eardley-Wilmot. *Mineral Ind.*, **44**, 1–12 (1935).—Consumption of abrasives increased in 1935, the auto industry being the largest consumer; 66,000 tons of abrasives were imported. Corundum comes principally from South Africa. A new abrasive (boron carbide) was developed. Sixty-five thousand tons of silicon carbide and fused alumina were imported, principally from Canada; 12,000 tons were exported. Improvements were made in grinding wheels due primarily to bond changes. A silicon carbide insert tooth disk for stone sawing was developed. G.M.P.

**Abrasive stones in phenolic resins.** Gaetano Gabardini. *Materie Plastiche*, No. 5, pp. 151–57 (1935); abstracted in *Bibliografia Ital. (Ingegneria)*, **9** [7–9] 58 (1936).—The advantages of the use of phenolic resins in the manufacture of abrasive stones, with special mention of the Nuvolac type, are given. The preparation of the mix consisting of the abrasive and the resin with the addition of small quantities of solvent, cold pressing in a hydraulic press, and firing with cautious regulation of time and temperature are described. M.V.C.

**American and British grinding machines.** Anon. *Schleif & Poliertech.*, **13** [11] 341–45 (1936). F.E.V.

**Deterioration of stamping machines by grinding heat.** E. Kaczmarek. *Schleif & Poliertech.*, **13** [11] 279–80 (1936). F.E.V.

**Fixed plane irons, grinding wheels, diamond tools.** Anon. *Schleif & Poliertech.*, **13** [11] 346–54 (1936). F.E.V.

**Grinding of:**

**Circular saws.** A. Dürr. *Schleif & Poliertech.*, **13** [11] 272–76 (1936).

**Countersinks.** E. Brödner. *Ibid.*, pp. 260–62.

**Cutters in general.** J. Horn. *Ibid.*, pp. 326–29.

**Diamond tools.** W. Winter. *Ibid.*, pp. 339–40.

**Drawing tools.** E. Horx. *Ibid.*, pp. 277–78.

**Hard metal tools.** F. Schwerdtfeger. *Ibid.*, pp. 293–96.

**High-speed tool steels.** W. Büttner. *Ibid.*, pp. 266–71.

**Lathe tools.** L. Obrusnik. *Ibid.*, pp. 287–92.

**Milled files.** H. Kotthaus. *Ibid.*, pp. 285–86.

**Milling cutters.** H. Klein. *Ibid.*, pp. 281–84.

**Reamers.** P. Buchholz. *Ibid.*, pp. 263–65.

**Scraping-out cutters.** A. Wagner. *Ibid.*, pp. 308–12.

**Screw taps.** R. Stopp. *Ibid.*, pp. 303–307.

**Stone cutter and quarry tools.** E. Probst. *Ibid.*, pp. 330–34.

**Tools.** H. Schallbroch. *Ibid.*, pp. 246–47; see "Boring—," *Ceram. Abs.*, **13** [3] 51 (1934).

**Twist drills.** H. Stoever. *Ibid.*, pp. 297–302. F.E.V.

**Grinding techniques of measuring apparatus.** G. Pallowitz. *Schleif & Poliertech.*, **13** [11] 257–59 (1936). F.E.V.

**Grinding wheels and their uses: I, Abrasive materials.** Johnson Heywood. *Abrasives*, **18** [1] 24 (1937).—Grindstones, which are composed of naturally bonded quartz, were the first abrasive tools used by man. In 1864 the emery wheel, the first aid to mass production, was invented; it made possible the manufacture of more accurate tools and the use of hard tool steel which had been impossible to sharpen. Emery has a variable chemical composition, but its abrasive qualities are due to its con-

tent of corundum which varies from 70 to 37%. Silicon carbide and aluminum oxide, developed more recently than emery, are much harder and more uniform. Silicon carbide is harder than aluminum oxide but not so tough. Silicon carbide wheels are used for grinding hard, brittle substances; aluminum oxide abrasives are used for cutting tough materials. M.C.S.

**Grinding woodworking tools.** K. RÖDER. *Schleif & Poliertech.*, **13** [11] 335–38 (1936). F.E.V.

**Hard metal tool shapes and their use in glassworking.** A. EWALD. *Schleif & Poliertech.*, **13** [11] 323–25 (1936). F.E.V.

**Organization of a tool grindery.** B. KONNOPASCH. *Schleif & Poliertech.*, **13** [11] 248–56 (1936). F.E.V.

**"Rolling" grinding. Work of the State Technical School at Zwiesel.** BRUNO MAUDER. *Sprechsaal*, **70** [5] 57–58 (1937).—"Rolling" grinding produces entirely rounded surfaces without edges. Various glasses treated by this method are described. Illustrated. See "Zwiesel—," *Ceram. Abs.*, **15** [7] 198 (1936). M.V.C.

**Sharpening saw teeth.** D. DOMINICUS. *Schleif & Poliertech.*, **13** [11] 313–18 (1936). F.E.V.

**Squaring up grinding disks.** K. DONATH. *Schleif & Poliertech.*, **13** [11] 319–22 (1936). F.E.V.

**Surfacing glass sheets with flexible drive grinding machines.** B. C. *Glaces & Verres*, No. 47, pp. 2–7 (1936).—Most grinding operations (surfacing, beveling, chamfering, grooving, etc.) are based on the principle of displacement of the glass specimen, the machine being stationary. By inversing this principle, the following improvements have been achieved in designing grinding machines and in the operation of grinding: (*a*) no manipulation of the glass sample worked on (it may be fragile or a heavy, cumbersome plate); (*b*) ease of operating the grinding machine which is equipped with a flexible shaft and supported in such a manner as to permit its displacement in any direction; and (*c*) important increase of the working speed which changes, in some cases, from 12 to 24 ft./min. to 40 to 100 ft./min. A complete description is given of the machine and of different types of tools used either for cutting or for drilling glass; *e.g.*, with a special silicon carbide-type wheel, 200 mm. in diameter and 6 mm. thick, revolving at 3000 r.p.m., glass may be sawed in the manner of a piece of timber at variable speed, according to the kind of glass experimented on: 4 to 5 ft./min. for plate glass $^{5}/_{16}$ in. thick, 6 to 7 ft./min. for opal plate $^{3}/_{8}$ in. thick, and $2^{1}/_{2}$ to 5 ft./min. for a plate $^{7}/_{8}$ in. thick. A $^{1}/_{2}$-in. hole can be bored in a $^{7}/_{8}$-in. thick opal plate glass in less than 3 min. R.W.D.

PATENTS

**Abrading machines.** W. W. TRIGGS (Norton Co.). Brit. 463,995, April 21, 1937 (Jan. 6, 1936).

**Abrasive article.** D. E. WEBSTER (Norton Co.). U. S. 2,078,354, April 27, 1937 (April 25, 1935). A grinding wheel having a peripheral cutting face and comprising a body of abrasive grains distributed in and bonded solely by vulcanized rubber and having a side layer of supplemental abrasive grains embedded in the rubber and abrasive body and solely bonded by the rubber thereof.

**Abrasive machine.** V. E. MINICH (American Foundry Equipment Co.). U. S. 2,077,638, April 20, 1937 (Oct. 20, 1934).

**Abrasive throwing machine.** V. E. MINICH (American Foundry Equipment Co.). U. S. 2,077,636, April 20, 1937 (May 26, 1934; Nov. 11, 1935). A machine for throwing abrasive at blasting velocities includes a tubular control member having a plurality of discharge openings diagonally offset with respect to one another, and throwing blades radially arranged around the member operative to throw the abrasive emitted from the openings.

**Abrasive throwing machine.** V. E. MINICH (American Foundry Equipment Co.). U. S. 2,077,637, April 20, 1937 (May 26, 1934; renewed Jan. 25, 1937).

**Abrasive throwing wheel.** V. E. MINICH (American Foundry Equipment Co.). U. S. 2,077,635, April 20, 1937 (June 21, 1935). An abrasive throwing wheel includes in combination spaced rotatably mounted side wall members, channel shaped throwing blades radially arranged between the side wall members and extending inwardly short of the axis of rotation of the wheel to define a central abrasive receiving space, a feed device for directing abrasive into the path of rotation of the blades, and spaced shouldered stud elements providing the sole means for connecting the side wall members in fixed spaced relationship.

**Abrasive wheel.** H. O. ANDERSON (Norton Co.). U. S. 2,078,437, April 27, 1937 (Oct. 25, 1935). An abrasive wheel comprises layers of open-mesh, flexible, textile material, abrasive grain stuck to the material with an artificial resinous bond, and a soft rubber matrix uniting the layers and the abrasive grain into an integral whole.

**Abrasive wheel and method of manufacture.** H. O. ANDERSON (Norton Co.). U. S. 2,078,436, April 27, 1937 (Oct. 25, 1935). An abrasive wheel comprises a spirally wound web of open-mesh leno impregnated with bond and abrasive grain, the wheel being cylindrical in shape, some abrasive grain existing in the plane of the leno.

**Apparatus for grinding end surfaces on the inside of ring-shaped bodies.** K. JUNG (trading as K. Jung Maschinenfabrik). Brit. 463,675, April 14, 1937 (March 2, 1935).

**Apparatus for producing grinding wheels.** W. S. RAE. U. S. 2,077,771, April 20, 1937 (June 16, 1932). A machine for producing a grindstone body from fibrous material and an abrasive substance comprises a thread-winding mechanism including pressure disks, means for delivering the abrasive substance to the winding mechanism, and pressure means for progressively embedding the abrasive substance into the thread being wound.

**Cam-grinding machine.** H. A. SILVEN (Norton Co.). U. S. 2,078,462, April 27, 1937 (March 27, 1935). U. S. 2,078,463, April 27, 1937 (Aug. 14, 1936).

**Drill-grinding apparatus.** H. E. TAUTZ. U. S. 2,080,515, May 18, 1937 (Feb. 2, 1934).

**Drill sharpener.** R. O. BAALMANN. U. S. 2,078,306, April 27, 1937 (Dec. 26, 1935).

**Grinding apparatus.** ENGELBERT MÜHLBACHER. U. S. 2,080,089, May 11, 1937 (March 17, 1934). In a control mechanism for grinders of the class described, a control arm has a pivot support at one end and contacting means at the opposite end designed to slidingly engage against the sides of a part to be ground.

**Grinding apparatus.** L. J. SAUER. U. S. 2,078,416,

April 27, 1937 (Feb. 6, 1936). A grinding apparatus for surfacing annular articles is described.

**Grinding disk.** H. W. H. Beth (Norton Co.). U. S. 2,078,120, April 20, 1937 (March 27, 1933).

**Grinding machine.** F. A. Ward (Gear Grinding Machine Co.). U. S. 2,077,727, April 20, 1937 (June 30, 1930).

**Grinding machine table reciprocating mechanism.** C. G. Flygare (Norton Co.). U. S. 2,078,757, April 27, 1937 (Nov. 20, 1936).

**Grinding or polishing machines.** Norton Co. Brit. 464,763, May 5, 1937 (Sept. 29, 1934).

**Hydraulically operated grinding and abrading machines.** Norton Co. Brit. 463,334, April 14, 1937 (Aug. 23, 1934).

**Hydraulically operated grinding machine.** W. H. Wood (Norton Co.). U. S. 2,078,749, April 27, 1937 (April 1, 1936).

**Lap-forming apparatus.** Jules Weinbrenner. U. S. 2,078,355, April 27, 1937 (Oct. 29, 1932).

**Machine for grinding rolls.** W. W. Triggs (Norton Co.). Brit. 464,455, April 28, 1937 (Jan. 1, 1936).

**Machine tools, more particularly thread-grinding machines.** H. Lindner. Brit. 464,332, April 28, 1937 (Aug. 2, 1935).

**Manufacture of abrasive articles.** R. C. Benner, O. L. Mahlman, and W. D. Rossow (Carborundum Co.). U. S. 2,078,830, April 27, 1937 (Dec. 6, 1934). An abrasive article comprises abrasive grain and a heat-hardened resin-containing bond modified by pulverized fused quartz.

**Presaponified buffing compound.** M. F. Hennessey (Puritan Mfg. Co.). U. S. 2,078,876, April 27, 1937 (Oct. 30, 1936). A solid abrasive preparation adapted to be deposited by friction upon a revolving buffing wheel comprises a fatty acid presaponified with a substance of the class represented by triethanolamine, monoethanolamine, diethanolamine, ethylene diamine, monoamylamine, diamylamine, and triamylamine, having mild detergent, emulsifying, and saponifying properties, and mixed with powdered abrasive.

**Production of abrasive material.** R. C. Benner and R. L. Melton (Carborundum Co.). U. S. 2,078,831, April 27, 1937 (Dec. 30, 1935). The method of making abrasive-coated products comprises coating a backing material with a liquid resin and applying abrasive grains and a catalyst for curing the resin to the resin-coated side of the backing to cause the resin to solidify and attach the abrasive grains firmly to the backing.

**Profile grinding machine.** H. Rammin. Brit. 463,767, April 21, 1937 (July 9, 1935).

**Pulpstone.** Thure Larsson (Norton Co.). U. S. 2,078,451, April 27, 1937 (Dec. 6, 1935).

**Pulpstone and filler therefor.** Thure Larsson (Norton Co.). U. S. 2,078,452, April 27, 1937 (Dec. 12, 1935).

**Reinforced grinding wheel.** Carl Wolf (Wolf's New Process Abrasive Wheel, Inc.). U. S. 2,080,156, May 11, 1937 (Aug. 15, 1936). In a tubular grinding wheel of solid molded abrasive material having a flat base, a wire embedded in the material adjacent the outer edge thereof, and a reinforcing plate having a converging inclined side section embracing the wire and having its outer surface flush with the base of the wheel.

**Roll-grinding machine.** A. G. Belden (Norton Co.). U. S. 2,078,705, April 27, 1937 (Dec. 24, 1935).

**Steadyrest for grinding machines.** A. G. Belden (Norton Co.). U. S. 2,078,556, April 27, 1937 (Dec. 5, 1935).

**Track grinder.** H. J. Perazzoli. U. S. 2,077,895, April 20, 1937 (Nov. 12, 1934).

**Truing apparatus for grinding wheels.** H. O. Kranich (Libbey-Owens-Ford Glass Co.). U. S. 2,079,076, May 4, 1937 (April 3, 1931).

## Art and Archeology

**Boeotian cup and a Hellenistic bronze.** Christine Alexander. *Bull. Metropolitan Mus. Art*, **32** [4] 90–91 (1937).—A Boeotian cup with grotesque figures is related to a series of vases called "Kabeiric ware" which, although they belong to the red-figured period, are painted in black figure. The inside and the handles are glazed black. Vines and figures are painted on the outside. A.A.A.

**Ceramics of old Egypt.** C. Steinbrucker. *Sprechsaal*, **69** [51] 755 (1936).—S. discusses old pottery of Egypt, some of it dating from B.C. 5000, exhibited at the Berlin State Museum. M.V.C.

**Discovery of a second flooring of Valencia tile in Venice.** L. Conton. *Corriere Ceram.*, **18** [2] 47–50 (1937).—The first discovery of a flooring of 14th Century Valencia tile was in the Justinian Chapel of the Church of Sant' Elena. A second flooring of the same period has been found in another chapel annexed to the same church. The tile are laid in an octagonal design composed of a central square surrounded by four elongated hexagonal pieces. The floral decoration and turquoise or light blue color applied by hand are of Spanish origin. Historical notes are given. M.V.C.

**Early terra cotta head.** G. M. A. Richter. *Bull. Metropolitan Mus. Art*, **31** [11] 235–37 (1936).—An early Greek terra cotta head is shown in the Room of Recent Accessions. The technique of the head is unusual. It was thrown on the wheel, and the features were either added to it or pushed out. Some traces of color are seen. A.A.A.

**English pottery; recent acquisitions.** C. Louise Avery. *Bull. Metropolitan Mus. Art*, **32** [3] 64–66 (1937).—Eighteen new pieces of English pottery have been added to the Museum's collections by R. Thornton Wilson and Carleton Macy. Six more have been purchased from a fund bequeathed by Anita M. Linzee. In the Macy collections are eight examples of salt glaze, a Staffordshire teapot, and four pieces of English delftware. Wilson has given seven pieces, including a small portrait bust of Charles I in blue and white Lambeth delft and three examples of Bristol ware. A delftware dish, a salt-glazed stoneware jug, a two-handled slipware cup (probably Staffordshire of about 1700), and three pieces of Bristol delft of about 1750 to 1760 are also included. See *Ceram. Abs.*, **16** [2] 55 (1937). A.A.A.

**Gift of pottery.** J. Downs. *Bull. Metropolitan Mus. Art*, **31** [11] 238 (1936).—Part of a dinner service made at

Leeds, England, in the late 18th Century has been presented by G. Creighton Webb. A.A.A.

**Horizontal handles for cups.** ANON. *China, Glass & Lamps*, **56** [8] 26–28 (1937).—Horizontal handles on cups have been introduced by the W. S. George Pottery Co. The new type handles make stacking easier and drinking more secure and comfortable than the vertical type. Types of cups have changed with drinking methods. Some of these were a heavy, handleless cup which required both hands, a cup held in the palm of the hand, stemmed bowls, beakers, horns, and handled mugs. The introduction of coffee and tea served hot required handles on the cups. These were placed perpendicularly for convenience in pouring the liquid into the saucer and not for drinking from the cup. Illustrated. G.M.P.

**Important loan of glass.** F. P. L. *Bull. Metropolitan Mus. Art*, **31** [11] 239 (1936).—Forty-nine choice pieces of glass have been loaned to the Museum by Ray Winfield Smith. Roman, Islamic, and an interesting example of Vexier glass are included. A.A.A.

**Learning display of china and glassware.** ANON. *China, Glass & Lamps*, **56** [8] 22–23 (1937).—Students of the New York School of Display make model window displays in three dimensions in the manner of small-scale stage sets, using illustrations from magazines and trade journals for material. Modeling clay is used to hold the figures upright. Illustrated. G.M.P.

**Monochrome geometric vases.** G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **32** [1] 9–10 (1937).—In the Room of Recent Accessions are two small handmade jugs, examples of a rare class of Greek pottery belonging to the 8th and early 7th centuries B.C. The clay is pale buff and the decoration is incised, partly by hand and partly by means of a cylinder. A.A.A.

**Pattern painting by spraying.** O. TH. KORITNIG. *Giesserei*, **24** [3] 59–61 (1937).—K. describes a spraying arrangement for nitrocellulose lacquers. M.H.

**Recently acquired Greek terra cottas.** C. ALEXANDER. *Bull. Metropolitan Mus. Art*, **32** [1] 17–18 (1937).—A miniature lady with disk body and pinched-up face from the tomb furniture of the Third Late Helladic period and an ox with horns have been added to the collection of Mycenaean statuettes. A primitive goddess and a statuette representing a woman sitting on a stool are also included. See "Four—," *Ceram. Abs.*, **16** [2] 55 (1937). A.A.A.

**Sandwich filigree glass.** M. S. DIMAND. *Bull. Metropolitan Mus. Art*, **31** [11] 244–45 (1936).—An interesting blown-glass flask in the American glass exhibit is ovoid in profile with flattened sides. A series of brightly colored spiral twists, in a variety of patterns, is embedded in the clear glass, making an interesting and distinguished effect. A.A.A.

**Silk-screen printing and its application to the dinnerware industry.** G. H. STAPLEFORD. *Bull. Amer. Ceram. Soc.*, **16** [5] 188–95 (1937).

**Stained glass windows to characters of fiction.** ANON. *Notes & Queries*, **171**, 391, 425 (1936); **172**, 33 (1937).—Windows such as those in Westminster Abbey depicting scenes from Bunyan's Pilgrim's Progress are described. H.H.S.

BOOKS

**Art of the Potter.** DORA M. BILLINGTON. Oxford Univ. Press, New York, 1937. 124 pp., 22 illustrations. Price $2.25. This is the fifth in a series of little craft books, the others being on bookbinding, weaving, lithography, and furniture. This little book was written only "for those who love pottery for its own sake, quite apart from its collection value. If beautiful pots were available for every one who could appreciate them, what a vitalizing influence this would have on the mass-produced article. Studio potters can only justify the making of pottery for the sake of its beauty if thereby they can bring beauty into the whole industry." This, the concluding paragraph, is the theme of the entire text and states the author's motive in giving briefly and in simple words the definition of pottery, description of materials, processes, and equipment employed, decorative styles, and means, and descriptive history of pottery development of all ages and peoples. B.'s chart of important dates in pottery development is excellent. Ceramic technology is not attempted. R. C. PURDY

**Chinese Ceramic Glazes.** A. L. HETHERINGTON. University Press, Cambridge; Macmillan Company, New York, 1937. 76 pp. Price $3.00. This book conveys in simple language the underlying scientific principles on which depend the chief glaze effects produced by the Chinese potters from the Han to the Manchu dynasties, a period extending over 2000 years. H. has given a scientific explanation for the several glaze and color effects obtained by the Chinese potters in language which those who are unfamiliar with chemical terms and reactions can understand. The investigations made by the late Herbert Jackson, J. W. Mellor, and the late Bernard Moore are described, and their conclusions are stated in a very understandable manner. Reactions such as oxidation and reduction are made interesting and instructive, even to those most familiar with them. The effect of firing and glaze composition on iron or copper is explained completely and simply. Discussions of opalescence, crackled glazes, iridescence, etc., are interestingly presented. The crackling of glazes is explained on the basis of volume changes, rather than on differences in coefficient of expansion between the body and the glaze.

Hetherington's glossary of terms and selected bibliography on Chinese pottery are very valuable. This book is worth $3.00 to anyone interested in art pottery and is worth many times this amount to those interested in the technical problems of pottery ware production, irrespective of its character. R. C. PURDY

**Golden Age of European Porcelain.** DUDLEY LEAVITT PICKMAN. Plimpton Press, Norwood, Mass., 1936. 118 illustrations (22 in full color), 191 pp. Price $10.00. This is a large financial contribution to students of ceramics in addition to a donation of a very readable digest of the history of porcelain making to which P. devoted many years of painstaking study and much money. This book is not available through bookstores, only through the Plimpton Press or the Museum of Fine Arts, Boston, Mass. The cost of printing this exquisite book was $20.00 per copy. Most of the standard books on the subject of porcelain, though indispensable for deeper study, are extremely diffuse in descriptive details and are often decidedly un-

wieldy for daily reference. The purpose of this small volume with its thoughtfully diversified illustrations is to give in condensed form an essence of information derived from the works of well-known authors such as Marryat, Binns, Burton, Jacquemart, and Garnier. Lack of space prevents consideration of various important factories, in England as well as on the Continent, where, however, reputation rests upon commercial rather than artistic success. Temptation to strain a point by including in the list certain interesting near-porcelain ware, among which Wedgwood is an outstanding example, was grudgingly resisted in order to preserve in these pages a strictly porcelainous summary.

Authorities agree fairly well as to the more essential facts in the history of porcelain production, but they often differ widely in their estimates of lesser matters. It would be a rather hopeless task, for instance, to attempt reconciling divergent views on the best period of a factory's product or the number of its authentic examples to be found in museums or private collections.

No attempt has been made to analyze or describe the composition of the various ware and the process of their manufacture, nor is any claim made to originality—unless, perhaps, the exercise of successful judgment in sifting and selecting available material may be considered an evidence of such quality.

The consequence of this plan is to present for the reader's consideration characteristic specimens of the foremost manufactures during the period indicated by the title, emphasizing more especially their range in form, design, and color, as well as the causes responsible for such varieties.

Considerable attention has also been given to the marks, for they often bear a close relation to the political history of a city or country at the time of the ware's production.

P. has in this book sketched the history of porcelain making from the beginning in all countries. He shows the influence of royal subsidies, jealousy, and armed conflicts. He brings out the fact that today there is nothing technically essential to porcelain ware production that is not well known. This book is a very valuable contribution to ceramics. R. C. PURDY

**History of York School of Glass Painting.** J. A. KNOWLES. S.P.C.K., London, 1936. Price £1/10s. Reviewed in *Notes & Queries*, **171**, 431–32 (Dec., 1936); see *Ceram. Abs.*, **15** [5] 141 (1936). H.H.S.

PATENTS

**Designs for:**

**Ashtray.** W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 104,168, April 20, 1937 (Feb. 23, 1937).

**Bottle.** W. A. HOLTZ (Owens-Illinois Glass Co.), U. S. 104,264, April 27, 1937 (March 19, 1937). P. G. LLOYD (Carr-Lowrey Glass Co.), U. S. 104,351, May 4, 1937 (Sept. 5, 1936). W. A. NESTER (Obear-Nester Glass Co.), U. S. 104,574, May 18, 1937 (March 25, 1937). P. E. ROEHRICH (Blake Mfg. Corp.), U. S. 104,474, May 11, 1937 (March 13, 1937). J. S. STEELMAN (Whitall Tatum Co.), U. S. 104,479, May 11, 1937 (March 27, 1937).

**Bowl.** J. E. DUNCAN, 3RD, AND R. A. MAY (Duncan & Miller Glass Co.). U. S. 104,343, May 4, 1937 (Dec. 2, 1936).

**Butter dish.** A. I. LORENZEN (Owens-Illinois Glass Co.). U. S. 104,164, April 20, 1937 (Feb. 25, 1937).

**Cake-box cover.** M. H. CONNOR (Owens-Illinois Can Co.). U. S. 104,442, May 11, 1937 (Sept. 30, 1936).

**Ceiling lighting fixture.** R. G. COWAN (Pass & Seymour, Inc.). U. S. 104,365 to 104,367, May 4, 1937 (Dec. 17, 1936).

**Comport.** W. C. MCCARTNEY. U. S. 104,573, May 18, 1937 (Feb. 16, 1937).

**Condiment shaker.** W. E. MACKELFRESH, JR. (Owens-Illinois Glass Co.). U. S. 104,167, April 20, 1937 (Feb. 23, 1937).

**Decanter.** GEORGE SMITH, JR. (Olean Glass Co.). U. S. 104,200, April 20, 1937 (March 10, 1937).

**Gas-heater casing.** R. G. CALTON (Tennessee Enamel Mfg. Co.). U. S. 104,439, May 11, 1937 (March 3, 1937).

**Glass bottle.** L. J. KIHN (J. T. & A. Hamilton Co.). U. S. 104,453, May 11, 1937 (Feb. 27, 1937).

**Glass liner for comport.** C. S. WHIPPLE. U. S. 104,175 and 104,176, April 20, 1937 (Feb. 24, 1937).

**Glass plate.** R. A. MAY (Duncan & Miller Glass Co.). U. S. 104,169, April 20, 1937 (Oct. 10, 1936).

**Jug.** J. C. KELLY. U. S. 104,452, May 11, 1937 (March 22, 1937).

**Lamp shade.** E. W. NEWTON (Imperial Glass Corp.). U. S. 104,222, April 20, 1937 (Aug. 6, 1936).

**Lighting unit.** C. F. HAAS (Westinghouse Electric & Mfg. Co.). U. S. 104,446 and 104,447, May 11, 1937 (Oct. 30, 1936).

**Plate.** DOUGLAS BOURNE (Onondaga Pottery Co.), U. S. 104,525, May 18, 1937 (Oct. 22, 1936). U. S. 104,553, May 18, 1937 (Oct. 8, 1936). YUKIO BUMA (Morimura Bros., Inc.), U. S. 104,528 to 104,538, May 18, 1937 (March 4, 1937). A. M. WALKER (Bailey-Walker China Co.), U. S. 104,594, May 18, 1937 (Feb. 26, 1937).

**Tumbler.** J. E. DUNCAN, 3RD, AND R. A. MAY (Duncan & Miller Glass Co.), U. S. 104,342, May 4, 1937 (Dec. 2, 1936). M. O. HANSEN (Libbey Glass Co.), U. S. 104,449, May 11, 1937 (March 19, 1937).

**Vase.** E. M. BOTTOME (Fostoria Glass Co.), U. S. 104,524, May 18, 1937 (April 10, 1937). A. I. LORENZEN AND M. S. DESSER (Owens-Illinois Glass Co.), U. S. 104,165 and 104,166, April 20, 1937 (Feb. 25, 1937).

**Firing colored decorations on or beneath the glaze of pottery.** KURT ULBRICHT. Ger. 628,657, April 8, 1936; Cl. 80*c*. 17.50; *Chem. Abs.*, **30**, 6156 (1936).—A method of effecting this process by direct heating in a muffle and other kiln is described.

**Metallizing porcelain.** HERMSDORF-SCHOMBURG-ISOLATOREN G. M. B. H. Ger. 628,842, April 17, 1936; Cl. 80*b*. 23.01; *Chem. Abs.*, **30**, 6155 (1936).—The parts of the porcelain to be metallized are glazed, roughened by a sand blast, and coated with a metal such as Zn or Cu by spraying with fused metal. The outer surface of the metal layer may be coated with a PhOH-$CH_2O$ insulating resin.

## Cements

**Effect of firing on clinker properties.** G. Mussgnug. *Zement*, **26** [1] 1–7; [2] 22–25 (1937).—Cements identical in every way show variable strength and contraction if the clinkering is different. M. made a series of tests on normal cements containing blast-furnace slags. To determine the degree of firing, the content of $SO_3$ in the clinker is the best criterion, low firing giving much sulfate. A strong apparent specific weight, grinding fineness being constant, is a sign of high firing. High-fired clinkers give less heat during hardening but contract more (counteracted by gypsum addition). Alkali content is practically independent of firing. Well-fired clinker is richer in alite and has less dicalcium silicate. Glass or free lime were never found. The sintering being secured, 1 to 1.5% $SO_3$ is the best proportion; the addition of gypsum must be about equal. During firing, the atmosphere should be oxidizing, with 2 to 3% $O_2$ in waste gas to avoid reduction to volatile sulfides. F.E.V.

**Formation of rings in revolving furnaces.** Carl Kjeldsen. *Tonind.-Ztg.*, **59** [102] 1246–48; [103] 1260 (1935).—The formation of rings is due not to coal ash alone but to a series of factors. It is a question of chemical uniformity and good preparation of raw materials, and even with these the ring formation is not entirely absent. The silica modulus in this case is as important as the fluxes, such as iron oxide, manganese, alkalis, titanic acid, and phosphoric acid, even if present in small quantities. M.V.C.

**Heat of formation of Portland cement clinker and calculation of exothermic reactions.** R. S. *Rev. Matériaux Construction Trav. Publics*, No. 329, pp. 27–28 (1937).—For determining exothermic reactions in the formation of a clinker of slag and lime (the same effects in the formation of a clinker of slag cement can also be determined), S. gives the following directions: (*a*) calculate the composition in combinations according to the method of Bogue; (*b*) calculate the metakaolin content in the raw powder by multiplying the percentage of $Al_2O_3$ in the clinker by 2.17; and (*c*) multiply, by the values in cal./gram of the table of the heats of formation, the quantities in grams of the compounds contained in 1 kg. clinker and add the products found. The exothermic effect of metakaolin is the product of 208 by the percentage of $Al_2O_3$ ($xp \cdot 100Al_2O_3 \times 2.17 \times 97.8$ cal. $= 208 \times xp \cdot 100Al_2O_3$) when practically all the alumina of the clinker is introduced in the form of kaolin and not by one of the compounds. M.V.C.

**Sulfo-aluminous and super-sulfated metallurgical cement.** Ettore Peretti. *Ingegnere*, No. 2, pp. 75–83 (1936); abstracted in *Bibliografia Ital.*, **9** [10–12] 68 (1936).—The preparation and characteristics of the product and the results of experimental tests are given. M.V.C.

**Winning and preparation of gypsum.** F. Gregor. *Ber. Deut. Keram. Ges.*, **17** [9] 444–46 (1936); see "Mining —," *Ceram Abs.*, **16** [3] 82 (1937). E.J.V.

**X-ray analysis in cement control.** Q. Sestini and L. Santarelli. *Chimica & Industria*, **18** [6] 277–85 (1936).—The development of X-ray examination for the constitution of cements and methods used in determination are reviewed and described at length. Photomicrographs illustrate the manner in which qualitative and, to some degree, quantitative measurements can be made. 18 references. M.H.

**X-ray characteristics of various forms of dicalcium silicate.** E. Brandenberger. *Schweiz. Mineralog. Petrog. Mitt.*, **14**, 473–77 (1935); *Chem. Abs.*, **30**, 667 (1936).—X-ray examination of $\alpha$-, $\beta$-, and $\gamma$-$Ca_2SiO_4$ shows them to be independent phases, but owing to the general weakness of the lines and their similarity to those of $Ca_3SiO_5$ the minimum amount detectable in a mixture is rather high. See "Crystal—," *Ceram. Abs.*, **16** [4] 109 (1937).

### PATENTS

**Acidproof and waterproof cement.** Foster D. Snell. Can. 354,624, Dec. 10, 1935; *Chem. Abs.*, **30**, 2345 (1936).—The density and hardness of cement are increased by the addition of 0.5 to 2% $Al(OH)_3$ to form an Al silicate in the cement; *e.g.*, a mixture comprises 100 parts ground siliceous material, 50 to 70 parts $Na_2SiO_3$, and 0.5 to 2.0% of a mixture of 4 parts $Na_2SiF_6$ and 5 parts $Al(OH)_3$.

**Manufacture of clay pozzolana.** H. Wagner. Brit. 463,453, April 14, 1937 (Dec. 4, 1934).

**Method of making high silica cement.** F. A. B. Finkeldey. U. S. 2,079,796, May 11, 1937 (June 21, 1935). In the manufacture of high-silica Portland-type cements by grinding of additional siliceous materials with finished Portland cement or clinker, the improvement comprises heating natural siliceous material to a red heat to increase its activity to reaction with lime, suddenly chilling the hot material before adding it to the cement or clinker, and grinding therewith.

## Enamel

**Cleansing sheet-iron ware before enameling.** Trost. *Beizerei* (in *Emailwaren Ind.*), **2** [2] 5–7 (1937).—T. gives directions for calcining and pickling sheet-iron ware. The composition of solutions used is analyzed. M.V.C.

**Controlled-atmosphere furnaces for annealing.** Wild-Barfield Electric Furnaces, Ltd. *Metal Ind.* [London], **49** [2] 34 (1936).—A vertical controlled-atmosphere electric furnace is described and illustrated. Unlike other types of furnaces, the heating elements, work, and atmosphere are in the same circulation. This scheme gives improved uniformity of temperature and furnace atmosphere. The system may also be applied to the bell-type furnace. H.E.S.

**Determination of iron in pickling solutions.** G. G. *Sprechsaal*, **70** [8] 99 (1937).—Potassium permanganate solutions for determining the iron content in pickling solutions are satisfactory only for laboratory methods and not for control analysis in plants. Potassium dichromate solutions are satisfactory in this case; they are easily prepared and very stable. The presence of chlorides does not

affect the dichromate titration. Orthophenanthroline is an excellent indicator whose color turns from red to blue on oxidation. Diphenylamine, another good indicator, turns from colorless to violet. M.V.C.

**Enamel mill-room practice with special reference to grinding mills.** G. STEELE AND W. MARSHALL. *Chem. Age*, **35**, 133–35 (1936); *Chem. Abs.*, **30**, 6610 (1936); see *Ceram. Abs.*, **16** [4] 110 (1937).

**Enamel as a substitute for noniron metals.** VIELHABER. *Emailwaren-Ind.*, **14** [6] 39–40 (1937).—V. briefly discusses the advantages of using enameled instead of unenameled articles. M.V.C.

**Enameled ware with designs.** W. O. *Emailwaren-Ind.*, **14** [7] 47–48 (1937).—Several German, French, and American patents dealing with the designs on enameled ware are discussed. M.V.C.

**Foundry-sand testing problems at high temperatures.** O. E. KYLE. *Trans. Amer. Foundrymen's Assn.*, **7** [6] 401–13 (1936).—K. reviews the published data on the properties of foundry sands at high temperatures. The data are plotted and the results are discussed. The drastic temperature effects are shown to be confined to a comparatively thin layer of sand adjacent to the casting. Test methods for determining conditions at elevated temperatures are described, *viz.*, tests for refractoriness, expansion and contraction, permeability, and compressive strength. Data on these tests are given and discussed. Lines of research needed to supply certain data are presented. H.E.S.

**Heat treatment of cast iron by hardening and tempering.** J. E. HURST. *Trans. Amer. Foundrymen's Assn.*, **7** [6] 373–400 (1936).—One of the outstanding developments in cast-iron metallurgy is the hardening and tempering of the material. H. discusses the effect of hardening and tempering on the mechanical properties, the effect of casting condition and composition on properties obtainable, and the effect of hardening and tempering on the stress-strain diagram and on the modulus of elasticity. The mechanism of hardening and tempering and the effect of carbon, carbon plus silicon, and quenching temperatures are also considered. The influence of chemical composition and alloy additions and their effect on the depth of hardening, the stabilizing effect of molybdenum on the strength of nitrogen-hardening cast iron, and the effect of alloys on quenching speed are dealt with. A discussion is included. H.E.S.

**Heating solutions in metal-cleaning tanks.** J. B. NEALEY. *Ind. Finishing*, **13** [5] 18–24 (1937).—N. describes gas-immersion heating as applied to metal-cleaning tanks. Gas burners are entirely inclosed so that no flame can come in contact with any inflammable vapors. The system can be used with lead pipes for heating acid pickling baths. Methods of installation and operation are considered. Illustrated. J.L.G.

**Metal-cleansing media.** VOIGT. *Sprechsaal*, **70** [3] 29–30 (1937).—Chief raw materials used for the manufacture of metal-cleansing materials are (1) wetting and emulsion media, (2) dissolving agents, (3) absorbing materials, (4) agents attacking chemically, and (5) those attacking mechanically. The effect of these types is discussed. M.V.C.

**Molding sand in the malleable iron foundry.** H. W. DIETERT AND F. VALTIER. *Trans. Amer. Foundrymen's Assn.*, **7** [6] 337–58 (1936).—Test data on thirteen foundry sands are plotted, showing various relations of sand properties to effects on castings produced. Synthetic sands are being used to a considerable extent. For smoothest casting surfaces, sands with low permeabilities are desired, and an approximate relation may be established between permeability and smoothness. Pyrometric control of metal temperature is now general in malleable foundries. Relationships shown by the data secured are discussed in detail. A discussion is included. See *Ceram. Abs.*, **16** [1] 9–10 (1937). H.E.S.

**Observations on foundry sands.** GROSS. *Rev. Fonderie Moderne*, **31**, 96–99 (1937).—The properties of sand suitable for molding purposes are discussed in general, and correct molding methods are described. M.H.

**Porcelain Enamel Institute Forum.** ANON. *Bull. Amer. Ceram. Soc.*, **16** [5] 227–28 (1937).

**Principles for pattern making guaranteeing simplest and economical production of cast goods.** F. PASCHKE. *Giesserei*, **24** [6] 136–38 (1937).—Examples illustrate modern principles of pattern making, which are characterized by the best subdivision of the mold and arrangement of the parts according to the properties of the metal used for the casting. M.H.

**Rejects in chill-mold castings of light alloys resulting from bad treatment of the molds.** SCHIED. *Rev. Fonderie Moderne*, **31**, 23–25 (1937).—Sound castings can be obtained more readily by preheating the mold to about 250°C, but this preheating must be absolutely uniform in the mold. Methods of heating are discussed briefly. M.H.

**Jacob J. Vollrath.** ANON. *Bull. Amer. Ceram. Soc.*, **16** [5] 226–27 (1937).

PREPRINTS

**Inhibitors in pickling.** E. JIMENO, I. GRIFOLL, AND F. R. MORAL. *Electrochem. Soc. Preprint*, 69—34, 9 pp. (1936). [illegible] were investigated with particular reference [illegible] at room and higher temperature [illegible] beneficial action of colloidal inhibitors depends on the adsorption of the inhibitor by the cathodic areas of the local cells or couples which are present on the surface of the metal. The assumption of the presence of such couples is supported by the presence of cathodic overvoltages and the absence of anodic overvoltages. The higher Fe oxides are reduced in spite of the presence of the inhibitor. The specific beneficial action of the inhibitor is the retardation of the evolution of H. There is a distinct parallelism between inhibitor action and H overvoltages.

**Inhibitors in pickling iron.** H. P. MUNGER. *Electrochem. Soc. Preprint*, 69—38, 19 pp. (1936).—The solution of scale on Fe in an acid solution gives an electrolytic cell with a comparatively high voltage. This potential difference combined with the intimate contact between the Fe base and the Fe oxide of the decomposed ferrous phase layer results in the rapid solution of this ferrous phase. Metallic inhibitors such as As protect Fe by plating out on the surface of the exposed Fe areas and, being negatively charged with respect to the Fe, prevent the discharge of H ion by their high H overvoltage. Organic inhibitors are adsorbed on the negatively charged cathode areas of the

Fe, after the scale has been removed, and eliminate H evolution by their change of the interfacial resistance and their specific effect on the discharge of H ions, the mechanism of which is not entirely understood. Inhibitors are useful in pickling operations if their cost is not too great or if their products do not interfere with subsequent fabrication of the steel. The organic inhibitors can not be used to prevent furnace pits and defects resulting from breaks in the scale before pickling. The high voltage developed by the scale-iron electrolytic cell appears to be too great for the inhibitor to prevent the electrochemical reaction between the acid, scale, and Fe. Blisters can largely be eliminated by inhibitors. The use of inhibitors in pickling steel preliminary to galvanizing and enameling must be watched carefully. In some cases no detrimental effects have been observed while in others the inhibitor has been found to be definitely harmful. Inhibitors, if used with intelligence, are valuable.

PATENTS

**Acid pickling inhibitor.** A. L. Wilson and A. B. Boese, Jr. (Union Carbide and Carbon Corp.). U. S. 2,080,553, May 18, 1937 (Nov. 15, 1934). A pickling bath for iron and steel products comprises an acid solution containing a small proportion of a parazine derivative having in the para position to the nitrogen an atom selected from the group consisting of nitrogen and sulfur.

**Art of utensil manufacture.** H. H. Maas (Vollrath Co.). U. S. 2,079,126, May 4, 1937 (March 9, 1936). The method of forming enameled ware consists in shaping a metallic vessel with a closed, annular, hollow bead, connecting a hollow, orificed handle element to the vessel and in communication with the interior of the bead, coating the vessel with enamel, firing the enamel, and causing gases formed in the bead during the firing step to flow into the handle element for discharge therefrom remote from the bead.

**Enameling iron.** Philipp Eyer. Ger. 628,487, April 4, 1936; Cl. 48*c*. 2.02; *Chem. Abs.*, **30**, 4642 (1936). Addition to 613,293 (*Ceram. Abs.*, **15** [8] 231 (1936)).—The process of Ger. 613,293 is modified by adding to the enamel about 3 to 10% of a compound of Ba, preferably a compound capable of combining with $SiO_2$, *e.g.*, BaO or $BaCO_3$. A small proportion of free ZnO may also be present. A specific composition is described.

**Enameling iron.** Ignaz Kreidl. Austrian 146,193, June 10, 1936; Cl. 48*c*.; *Chem. Abs.*, **30**, 6158 (1936). Addition to Austrian 136,003 (*Ceram. Abs.*, **13** [10] 252 (1934)). Ger. 629,797, May 12, 1936; Cl. 48*c*. 1; *Chem. Abs.*, **30**, 6158 (1936). Addition to Ger. 609,165 (*Ceram. Abs.*, **14** [9] 211 (1935)).

**Enameling metal surfaces.** Hugo Debach. Ger. 629,631, May 11, 1936; Cl. 48*c*. 3; *Chem. Abs.*, **30**, 6157 (1936). Addition to 516,607 (*Ceram. Abs.*, **10** [8] 550 (1931)).—The metal compounds for giving coloring to the enamel are produced on the surface to be enameled by thermal methods. Thus, a $Cu_2O$ layer may be produced on a Cu surface by heating, and this colors the enamel.

**Enamels.** Ignaz Kreidl. Austrian 146,190, June 10, 1936; Cl. 48*c*.; *Chem. Abs.*, **30**, 6156 (1936).—As agents for producing white opaque effects in enamels, use is made of hydrocarbons of high molecular weight or their substitution products, *e.g.*, resin, pitch, tar, or asphalt. The opacifying action is effected by the gases evolved by these agents when the enamels are fired. A specific composition is described.

**Method and composition for coating iron and steel articles.** Mark Weisberg and Louis Corman (Alrose Chemical Co.). U. S. 2,077,450, April 20, 1937 (Jan. 8, 1935). The method of surface-treating ferrous metal articles comprises immersing the articles in an aqueous solution of an alkali and an oxidizing agent and regenerating the bath by adding an activating agent differing in chemical composition from either of the two aforesaid substances and capable of forming complex ions with ions of iron resulting from previous operation and preventing them from inhibiting the further operation of the unspent bath.

**Opaque vitreous enamel composition.** R. R. Shively (B. F. Drakenfeld & Co., Inc.). U. S. 2,079,339, May 4, 1937 (Aug. 27, 1934). A composition is given for the production of a vitrifiable enamel comprising lead borate and a compound of the group consisting of lead phosphomolybdate, lead phosphotungstate, and lead phosphovanadate.

## Glass

**Basis of a standard test for chemical durability of glass bottles.** W. E. S. Turner (associated with H. S. Blackmore, V. Dimbleby, H. S. Y. Gill, H. W. Howes, and W. J. A. Warren). *Jour. Soc. Glass Tech.*, **19**, 171–88 (1935).—T. presents an outline record of the leading features of the work involved in providing data on which to base a standard test for the chemical durability of glass in the form of containers. No satisfactory test appears possible which does not impose meticulous care both in the selection of test pieces and in the conditions of carrying out the test. The test pieces must be of standard capacity and dimensions, and the conditions of annealing and of storage should be known. Constant conditions of treatment with water at or near the boiling point can best be obtained by immersion in steam from boiling water in a nearly closed boiler. Small variations of barometric pressure were found to be without sensible influence. The amount of alkali extracted by water is proportional to the area of the surface exposed in the case of bottles varying from 1 to 20 oz. nominal capacity, while the concentration of alkali in the extract constantly diminishes. Results are recorded illustrating the conditions which influence variations with individual bottles, variation with different observers, and the effects of time of treatment by water, chemical composition, age, and storage. The visible effects of corrosion, in particular pitting, flaking, and cracking, are discussed in relation to glass composition and treatment. See *Ceram. Abs.*, **14** [7] 159 (1935).

**Change of transmission of glasses with temperature below and above the transformation point.** A. Klemm and E. Berger. *Glastech. Ber.*, **14** [6] 194–206 (1936).—From numerous measurements on colorless and colored glasses at high temperatures, it was found that the temperature coefficient of transmission or of the wave-length

having the same extinction changes suddenly at the transformation point. Contrary to other properties, such as index or density, the colorless glasses showed that the transmission was unrelated to previous heat treatment. A well-annealed glass test piece shows, at room temperature as well as at higher temperatures, the same transmission as a previously quenched specimen from the same melt, but it shows a marked change in index, density, and double refraction. The same holds true for a series of colored glasses. Since, however, the wave-length, $\lambda_e$, for fixed values of transmission in relation to temperature showed sudden changes in their temperature coefficient, $d\lambda_e/dt$, it follows that the bend points and especially the transformation points are not limited by fixation of the internal chemical state, because such a process is not noticeable in the transmission of most glasses. The bend points are therefore to be explained as purely physical. It is important that many colored glasses show a significant dependence of transmission on the previous heat treatment. In these cases, the atoms of coloring material are accordingly so built-up into the glass framework that they are influenced by the internal chemical changes which have occurred. Since these are fixed, a part of the changes of transmission ability is also fixed. Only this portion (which, in contrast to the purely physical changes obtained by heating, is comparatively small) is included in the study of the changes of molecular structure occurring in certain glasses at high temperatures. It is similar to the resulting changes produced by quenching in index, density, viscosity, electrical conductivity, etc., and to certain pure chemical influences of these properties by changes in composition. Further studies must show whether an insight into the chemical nature of the glassy state is to be obtained in this way. 20 references. G.R.S.

**Channel cooling furnace for simultaneous cooling of different glasses.** Hermann Passauer. *Glashütte*, **67** [11] 187–89; [12] 206–209 (1937).—Problems connected with the cooling of different types of glasses as they are met in hollow glassworks are discussed. Various cooling furnaces used in practice which permit the simultaneous cooling of various types of hollow glassware in one furnace are described on the basis of "cooling" curves. These cooling curves must be determined experimentally for each kind of glass and are important. M.V.C.

**Chemical compositions and water solubilities of glasses: I.** S. Nagai and Y. Mikami. *Jour. Japan. Ceram. Assn.*, **42**, 399 (1934); *Jour. Soc. Glass Tech.*, **18**, 427–28A (1934).—A series of simple glasses was prepared, based on a parent glass, $SiO_2$ 72, CaO 13, and $Na_2O$ 15%, in which $Al_2O_3$ and MgO were introduced. The solubilities of the glasses in water were determined on the glass in grain form (1) in the autoclave at pressures of 5, 10, 15, and 20 atmospheres, and (2) in water in a silver beaker heated on a water bath for 2 hr. Two grain sizes were used: between 64- and 144-mesh/sq.cm., and between 144- and 225-mesh /sq.cm. The solubilities were measured by the titration of the resulting solutions against $N/50$ $H_2SO_4$. The compositions of the glasses are cited, but they do not correspond with those intended, and comparison is difficult. It is concluded, however, that $Al_2O_3$ confers resistance to water attack, while MgO, on the whole, is not quite equal to lime in this respect. **II.** Shoichiro Nagai and Yoshio Kato. *Jour. Japan. Ceram. Assn.*, **43**, 719–30 (1935); *Chem. Abs.*, **30**, 2336 (1936).—In an ordinary $Na_2O$-CaO glass, the $SiO_2$ and $Na_2O$ were held constant at 72 and 15%, respectively, and the 13% CaO was replaced in varying amounts by BaO, MgO, or ZnO. The BaO and ZnO increased the specific gravity while MgO decreased it. Data are tabulated. The better glasses contain 6 to 8% $B_2O_3$, 4 to 6% ZnO, 3 to 8% $Al_2O_3$, and only small amounts of CaO (1 to 3%). Two glasses prepared by the authors showed high insolubility, comparing favorably with the best of the above; no analyses are given. For Parts III–IV see *Ceram. Abs.*, **16** [3] 85 (1937).

**Chemistry of colored glass: II.** Woldemar Weyl. *Glass Ind.*, **18** [4] 117–20 (1937).—W. discusses chromium, manganese, iron, vanadium, uranium, and copper glasses and the oxidation-reduction equilibria of these oxides. Using chromium glasses as an example, he shows how the chromic-chromate equilibrium in glass can be determined and how it is then possible to check the influence of different factors upon the position of this equilibrium. For Part I see *Ceram. Abs.*, **16** [6] 170 (1937). E.J.V.

**Considerations in developing a mineral wool industry.** C. F. Fryling and O. White. *Chem. & Met. Eng.*, **42** [10] 550 (1935).—Mineral wool or rock wool was first found during the depression of 1896 and has been gradually developed until today it has a definite place in the list of structural materials. The material has many properties which make it desirable for construction purposes: (1) it is an effective heat insulator, (2) it does not deteriorate, and (3) it is waterproof, fireproof, and vermin-proof. The process of manufacturing this product consists in melting a mixture of rock or slag and coke in a cupola at a temperature of about 1500°C. The melt flows out through the bottom of the cupola in a steady stream and, at the point of emission, a steam blast at about 100-lb. pressure is impelled into it at right angles to it. This action causes the melt to string out into very fine threads which, upon cooling, are used in preparing the various wool products. M.C.S.

**Continuous tank furnace with passages.** Otto Geiler. *Sprechsaal*, **69** [27] 391 (1936).—G. gives a brief description of the construction and operation of a continuous tank furnace with passages. This furnace is divided into three separate tanks, (1) melting, (2) refining, and (3) working tanks. Illustrated. M.V.C.

**Experience with automatic regulators on glassmelting furnaces.** W. Büssing. *Glastech. Ber.*, **14** [6] 212–19 (1936).—In the last few years remarkable progress has been made with the development of regulators for glassmelting furnaces. The development and experience in this special field are reported, and references are given concerning the construction of mixing, temperature, and pressure regulators. Diagrams show the construction and operation of the devices. G.R.S.

**Filter of Pyrex brand glass and stainless steel for use with Seitz filter pads.** Bert C. J., G. Knight, and Paul Fildes. *Biochem. Jour.*, **30**, 1138–39 (1936); *Chem. Abs.*, **30**, 6609 (1936).—A diagram and complete details are given. The advantages are ease of cleaning and avoidance of toxic metal contamination.

**Glass apparatus for water distillation.** Paul Eilers and Bernhard Siede. *Apoth. Ztg.*, **51**, 469–70 (1936);

*Chem. Abs.*, **30**, 4053 (1936).—A specially constructed type of verticle worm condenser has an enlarged upper portion filled with glass globules. Blown into the upper side and attached thereto by a narrow U-tube is a distilling bulb, the upper end of which connects by a wide bent tube with the top of a condenser. The distilling bulb is surrounded by a metal chimney designed to conserve heat as applied.

**Glass at the exhibition of British art in industry.** J. H. HOGAN. *Jour. Soc. Glass Tech.*, **19**, 167–70 (1935).—H. reviews the main features of the exhibits of glassware shown at the Exhibition of Industrial Art held in January, 1935, and discusses some of the lessons to be learned.

**Glass from potato flour.** ANON. *Chem. Weekblad*, **34** [12] 221–22 (1937).—Researches into the possible utilization of large quantities of potato flour led to the discovery of a process (not described) for making a glass of this material which is less breakable than ordinary window glass and which more easily transmits rays of short wavelengths; the shortest length passing through the glass is 290 $\mu\mu$, while ordinary glass transmits rays of 320 $\mu\mu$ and over. The material can be worked mechanically, *e.g.*, polished, sawed, drilled, etc. M.H.

**History of the Braunschweig glassworks in Solling, 1743–1842.** EBERHARD TACKE. *Sprechsaal*, **70** [1] 3–5; [3] 27–29 (1937).—T. gives the history of the old German glass industry. M.V.C.

**Laminated safety glass.** J. W. H. RANDALL. *Chemist*, **12** [9] 367–73 (1935).—R. gives the history of safety glass, together with a discussion of bullet-proof glass.

**Luminous glass architecture seen as next step in "Glassical Age."** H. M. ALEXANDER. *Amer. Glass Rev.*, **56** [18] 20 (1937).—A. predicts a widespread adoption of the various structural glasses by the architects for future buildings. References are made specifically to Akro, Tuf-Flex, and Enameled Tuf-Flex glasses, and their possibilities as structural materials are noted. Such glasses will afford more effective lighting and produce more interesting architectural effects. M.C.S.

**Phosphorescent glasses. Influence of crystallization.** M. CURIE. *Compt. Rend.*, **204** [5] 352–53 (1937).—An ordinary glass which showed a fairly strong green fluorescence but no visible phosphorescence was annealed for four days at 800°C so that it crystallized entirely. It then showed green phosphorescence and thermoluminescence; when the crystallization was further improved by addition to the glass of 1% $CaF_2$, these two properties were considerably strengthened. Additions of Mn, Bi, Sm, and U increased the phosphorescence and fluorescence greatly and changed the color of fluorescence. The range of the spectrum was determined in each case. See *Ceram. Abs.*, **16** [4] 135 (1937). M.H.

**Physical methods for control work.** ANON. *Glass Ind.*, **18** [4] 125–28 (1937).—Quick tests simply carried out are described. Comparisons of expansion of different glasses are made by a welding test in which the ends of the two glasses are welded together and a thread of the two is then drawn. On cooling, this thread curves if the coefficients of expansion are not the same, the glass of higher expansion being on the inside of the curve. Specific gravity can be checked by the flotation method, specific gravity of the liquid in which the glass floats being checked with a Westphal balance. The Littleton softening-point tests serve as control tests for composition changes. The central illumination or Becke method and the Abbé refractometer method of determining refractive index are described. E.J.V.

**Preparation, working, and use of spun glass.** G. V. PAZSICZKY. *Glastech. Ber.*, **14** [6] 206–11 (1936).—A description is given of the following methods of preparation and devices used in the manufacture of spun glass (glass silk and glass wool): (1) drawing out of individual (*a*) smooth or (*b*) corrugated threads from one or more glass rods, and (2) simultaneous production of numerous threads by (*a*) rolling or (*b*) blowing. Mention is made of the further working up and use of spun glass. G.R.S.

**Purpose and shape of the most usual, general glass apparatus in the laboratory.** ANON. *Glas & Apparat*, **17** [18] 157–59; [19] 167–69; [20] 177–79; [21] 189–91 (1936).—An exhaustive review and complete description of apparatus used in modern laboratories for metallurgical, physical, chemical, and ceramic work are given. M.H.

**Research methods for the study of glass currents in tank furnaces.** W. SCHNEEKLOTH AND W. SPIELVOGEL. *Glastech. Ber.*, **15** [1] 1–14 (1937).—New methods for the systematic research on current conditions in glass-tank furnaces were devised because of the high temperature and great viscosity of the glass and the attack by the glass on the research apparatus. Difficulties arose from the inability to approach the furnace and unavoidable disturbance of the glass manufacturing process. During the last ten years, a series of research methods has been developed, which agreed in the recognition of the significance of the convection currents contrasted to drawing currents and showed that the unavoidable currents might be made useful in the melting process. Through the observation of floating bodies, the direction and speed of the surface currents were estimated. Deeper submerged floats and vanes gave indications of the strength and average speed of the chief current and made visible proof of the circular course of the back currents in deeper parts of the glass tank. The observation of the gradually changing composition of the glass worked out, by changing the batch additions while the operation was in process, supplemented these results. In cooled tanks, crystallization phenomena and additions of colored glass before cooling led to valuable results. The drill-hole process gave indications of the back currents in the passage between double tanks. G.R.S.

**Safety glass.** J. H. SHERTS AND E. L. FIX. *Chem. & Met. Eng.*, **43** [4] 177 (1936).—A safety glass with a new sandwich material, Vinylite X, appears to have properties superior to any similar glass yet produced. Glass so produced is 10 times as resistant to the drop of the $^1/_2$-lb. steel ball at 0°C as other types of safety glass, 4 times as resistant at 70°F, and 3 times as resistant at 110°F. The plastic material shows practically no discoloration after 1000 hr. exposure to the Uviarc test and no color change after two years' flat exposure to the Florida sun. M.C.S.

**Sapphire and other new combustion-chamber window materials.** G. CALINGAERT, S. D. HORTON, AND R. STAIR. *S. A. E. Jour.*, **39**, 448–50 (1936); *Brit. Chem. Abs.-B*, **56**, 136 (1937).—A study was made of the properties, *e.g.*, mechanical strength, limits of transparency, and resist-

ance to attack by PbO or $CO_2$ of quartz, spinel, sapphire, periclase, fluorite, and rock salt. Sapphire was not attacked by combustion products from petrol containing Pb.

**Scattering of light in optical glasses.** R. S. KRISHNAN. *Proc. Indian Acad. Sci.*, **3** [3] 211–20 (1936).—A comparative study has been made of the intensity and state of polarization of the light scattered transversely by a series of seventeen glasses of optical quality, with the incident light in different states of polarization, *viz.*, unpolarized, vertically polarized, and horizontally polarized. A weak fluorescence was observed in all the glasses. Measurements of the depolarization factors $\rho_u$, $\rho_v$, and $\rho_h$ were made with an orange filter in the path of the incident beam to eliminate fluorescence. $\rho_u$ and $\rho_v$ are found to be of the same order of magnitude as is usually observed in the case of gases. On the other hand, $\rho_h$ is found to be distinctly less than 100%, showing thereby the existence of molecular aggregates, not small in size compared with the wave-length of light. Since no visible inclusions are observed, it is concluded that the scattering in glass is really an internal phenomenon. Measurements of the relative intensity of scattering in these glasses were also made employing the photoelectric method. The influence of the composition of the glass on the formation and size of the molecular aggregates is fully discussed. The tendency of molecular aggregates to form increases with an increasing percentage of acidic oxides, especially boric oxide, whereas it diminishes as the glass becomes more basic. A.P.S.

**Securit safety glass.** B. L. *Glaces & Verres*, No. 49, pp. 7–11 (1937).—The physical properties and characteristics of Securit safety glass are given. R.W.D.

**Simple testing of glass for resistance to atmospheric conditions.** FRITZ STEIN. *Glashütte*, **67** [8] 130–31 (1937).—The resistance of glass to atmospheric conditions is based on acid testing. The hydrochloric acid method of R. Weber (*Dinglers polytech. Jour.*, **171**, 129 (1863)) and the hydrochloric surface treatment belong to this method. The weathering experiment of F. Späte (*Ceram. Abs.*, **6** [5] 172 (1927)) is based on the effect of atmosphere containing carbonic acid and saturated with water steam at room temperature. The use of tropical temperature to determine the stability of glass in the space where the glass is tested is suitable; chiefly glasses containing boric acid and zinc are tested by this method. The narcotin test, used for medicine glass, as a standard method yields good results, although it is used in this case to determine the effect of cold water. M.V.C.

**Studies on glass: XI, Thermodynamic relations of glassy and alpha-crystalline glucose.** GEORGE S. PARKS, L. J. SNYDER, AND FRANCIS R. CATTOIR. *Jour. Chem. Phys.*, **2** [9] 595–98 (1934).—Although the properties of a glass depend to some extent upon its thermal history, fairly satisfactory thermal data can be obtained for well-annealed glasses. In the present study, the difference between the heat contents of glucose glass and $\alpha$-crystals has been determined calorimetrically at 20°C and, with the aid of this result, the corresponding differences in entropy and free energy have also been computed. The value for this last quantity is $\Delta F°_{293} = 1670$ cal./mol. Solubility measurements have been made for glucose $\alpha$-crystals and glass in methyl, ethyl, and isopropyl alcohols at 20°. The free energy values thereby obtained for the conversion of $\alpha$-crystals into glassy glucose are in good agreement with the preceding value derived from the thermal data. **XV, Viscosity and rigidity of glucose glass.** GEORGE S. PARKS AND JOHN D. REAGH. *Ibid.*, **5** [5] 364–67 (1937).—By an electromagnetic torsion method, in which glucose threads were substituted for the phosphor-bronze suspension in a D'Arsonnal galvanometer, the rigidity and viscosity of glucose glass have been measured between 12° and 37.5°C. The rigidity values were fairly constant around $2.5(10^{10})$ dynes per cm.$^2$ between 12° and 30° but decreased rapidly above the latter temperature. The viscosity values ranged between $10^{13}$ and $10^{19}$ poises. These values decreased rapidly with rising temperature but also depended greatly on the previous history of the glass threads, *i.e.*, the extent to which the threads had been annealed and the amount of previous working to which they had been subjected. This finding suggests the existence of a series of glassy states for a substance such as amorphous glucose. For Part **VIII** see *Ceram. Abs.*, **13** [7] 194 (1934). G.R.S.

**Study of brilliance exhibited by lead crystal glasses.** ERIC PRESTON, A. J. HOLLAND, AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **19**, 125–38 (1935).—Thirteen specimens of cut crystal glassware have been examined for general appearance, chemical composition, and angle of cut. The decolorizer, where employed, appeared in all cases to be manganese; in three specimens, only arsenic was found, and in two, traces of nickel were present in addition to manganese, but no other decolorizers were found. The angles of cutting differed greatly. British samples had the widest angle, partly accounting for the lack of high internal reflection and apparent brilliance such as was secured by the narrow angle of cut of a Belgian piece. Proofs taken from melts at various times during the working of a pot and examined for iron oxide content supported previous experience and results in showing an increase of the iron oxide content on standing. Examination of the cut and polished surfaces under the microscope made it possible to criticize the care with which the cutting and polishing processes had been carried on.

**Tank furnace with different depths.** M. D. TAMARIN. *Keram. & Steklo*, **11** [10] 16–20 (1935).—T. discusses the problem of melting glass in tank furnaces having different depths and in which the melting zone is deeper than the refining and working zones. The practical criteria for selecting the maximum depth of the tank are (1) uniformity of cooling and (2) lack of layers of "dead" glass which can be determined by measuring the temperature of the glass in the various depths of the tank or by practical observation of melting. M.V.C.

**Thermo-insulating wool from slags rich in manganese.** P. G. REZNIKOV. *Stroitel. Materialy*, No. 11, pp. 49–54 (1936).—Slags from the production of ferromanganese in electrical furnaces were used (MnO 18 to 30%, $SiO_2$ 25 to 32%). Wool of a relatively high volume weight (up to 680 kg./m.$^3$) was obtained, suitable as a sound-insulating material. The hygroscopicity is slight. The thermal conductivity coefficient varies from 0.05 to 0.07 at 100°. P.B. & E.S.

**200-inch telescope disk.** G. V. MCCAULEY. *Jour.*

*Soc. Glass Tech.*, **19**, 156–66 (1935); see *Bull. Amer. Ceram. Soc.*, **14** [9] 300–22 (1935).

**Volatility of soda-lime-silica glasses.** H. W. Howes, H. Laithwaite, Eric Preston, and W. E. S. Turner. *Jour. Soc. Glass Tech.*, **19**, 104–18 (1935).—The conditions which must be observed in studying the volatilization from glasses at temperatures up to 1400° are given. These conditions include the shape of the containing vessel and the furnace conditions, as both influence the rate of diffusion of vapor from above the glass surface. The losses of platinum were determined at different temperatures. The presence of volatile constituents such as $As_2O_3$, $SO_2$, and traces of moisture increases the initial rate of volatilization and must be guarded against. Under a fixed set of conditions, the rate of volatilization is proportional to the area of the surface exposed. The volatilization losses from the glass, $SiO_2$ 73.35, $Fe_2O_3$ + $Al_2O_3$ 0.40, CaO 9.90, $Na_2O$ 15.94%, prepared so as to be free from all but possible traces of the volatile constituents $H_2O$ and $CO_2$, were studied and, for the first 20 hours in each case, were found to be 1.7 mg./cm.$^2$ at 1400°, 0.69 at 1300°, 0.31 at 1200°, and 0.1 at 1100°. It was confirmed that up to 1400° only $Na_2O$ was volatilized.

PATENTS

**Apparatus for:**

**Cooling glassware.** United Glass Bottle Manufacturers, Ltd. Ger. 629,853, May 15, 1936; Cl. 32*a*. 29; *Chem. Abs.*, **30**, 6155 (1936).

**Feeding molten glass.** G. T. Meyers. U. S. 2,079,519, May 4, 1937 (May 7, 1936).

**Hardening glass.** Herzogenrather Glaswerke Bicheroux & Cie. G.m.b.H. Ger. 628,570, April 16, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **30**, 6154 (1936).

**Making glass.** Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St.-Gobain, Chauny & Cirey. Ger. 629,818, May 13, 1936; Cl. 32*a*. 24.02; *Chem. Abs.*, **30**, 6154 (1936). Addition to Ger. 620,650 (*Ceram. Abs.*, **15** [8] 238 (1936)).

**Making glass beakers, etc.** Libbey Glass Mfg. Co. Ger. 628,666, April 15, 1936; Cl. 32*a*. 27; *Chem. Abs.*, **30**, 6154 (1936).

**Shaping glass.** Angermann & Keppler. Ger. 627,815, March 27, 1936; Cl. 32*a*. 15; *Chem. Abs.*, **30**, 6154 (1936).

**Tempering glass plates and sheets.** American Securit Co. Brit. 464,057, April 21, 1937 (Oct. 13, 1934).

**Colored glass.** Soc. Anon. Holbrever. Fr. 46,089, Feb. 15, 1936; *Chem. Abs.*, **30**, 6155 (1936). Addition to Fr. 775,955 (*Ceram. Abs.*, **14** [9] 215 (1935)).—Glass containing a dye is added to the glass to be colored in the form of a thin sheet and the two are heated together and mixed.

**Colored glass, etc.** E. I. du Pont de Nemours & Co., Inc. Fr. 792,417, Dec. 31, 1935; *Chem. Abs.*, **30**, 3958 (1936).—In addition to the usual CdS and Se, the presence of a further amount of Cd, preferably as metal, gives a red color to glass, glazes, etc., without the usual further heating after cooling. Instead of Cd, Cd selenide may be used, but the presence of reducing agents other than Se is necessary. If Cd sulfoselenide and Cd is used, the presence of CdS and Se is not necessary.

**Decorative glass panel and process for its manufacture.** Oxvar, Ltd. (Oxford Varnish Corp.). Brit. 463,588, April 14, 1937 (March 10, 1936).

**Device for coating glass with synthetic resin, etc.** Corning Glass Works. Ger. 628,506, April 6, 1936; Cl. 39*a*. 19.05; *Chem. Abs.*, **30**, 6155 (1936).

**Edge-grinding machine.** N. H. Klages (G. W. Klages & Son). U. S. 2,080,280, May 11, 1937 (Aug. 19, 1935).

**Floating quartz partition for glassmelting tank.** Deutsche Libbey-Owens-Ges. für Maschinelle Glasherstellung A.-G. Ger. 631,040, June 11, 1936; Cl. 32*a*. 23.03; *Chem. Abs.*, **30**, 6154 (1936).

**Gas-tight covers for annealing furnaces.** Luise Russ (née Delmhorst). Ger. 627,750, March 23, 1936; Cl. 18*c*. 8.90; *Chem. Abs.*, **30**, 5842 (1936).

**Glass.** N. V. Philips' Gloeilampenfabrieken (Gottfried B. Jonas, inventor). Ger. 629,745, May 9, 1936; Cl. 32*a*. 35; *Chem. Abs.*, **30**, 6154 (1936).—Objects made partly of quartz and partly of glass (except electrical vacuum tubes) are fused together by the aid of an intermediate glass containing a high per cent of $SiO_2$, more than 4% of $B_2O_3$, and 1 to 5% of one or more oxides of Ca and Mg and which is practically free from oxides of the alkali metals. Thus, such an intermediate glass contains $SiO_2$ 85, $B_2O_3$ 12.5, and CaO 2.5%.

**Glass composition.** Kitsuzo Fuwa and Fujio Suzuki (General Electric Co.). U. S. 2,080,262, May 11, 1937 (Sept. 14, 1936). A glass composition has a silica content of more than 77.5%, an alkali oxide content of less than 5.5, and a zinc oxide content of more than 0.1 and less than 1%.

**Glass-forming machine.** Arthur S. Jackson and Carl W. Hale (Owens-Illinois Glass Co.). Can. 354,697, Dec. 10, 1935; *Chem. Abs.*, **30**, 2340 (1936).—Various structural details of the mold and supports are described.

**Glassmelting furnace with outlet nozzles for making filaments.** Glasfabrik Wilhelmshütte G.m.b.H. Ger. 631,310, June 17, 1936; Cl. 32*a*. 25; *Chem. Abs.*, **30**, 6154 (1936).

**Glass-to-metal seal.** British Thomson-Houston Co., Ltd. Brit. 463,335, April 14, 1937 (Oct. 4, 1934). W. A. Ruggles (General Electric Co.). U. S. 2,078,776, April 27, 1937 (Sept. 1, 1934).

**Glass-molding apparatus.** Karl Zumpe. Ger. 628,665, April 8, 1936; Cl. 32*a*. 7; *Chem. Abs.*, **30**, 6154 (1936).

**Glass pipe lines.** Neue Glasindustrie-Ges., Ges. Brit. 457,143, Dec. 2, 1936 (June 6, 1934).

**Glass-pressing machine.** Edward Miller (Lynch Corp.). Can. 359,260, July 21, 1936; *Chem. Abs.*, **30**, 6155 (1936).—Structural details are described of an apparatus for varying the pressure of the plunger by one or more cylinders with pistons of varying capacity.

**Glassware leer construction.** D. G. Merrill (Hartford-Empire Co.). U. S. 2,079,559, May 4, 1937 (Feb. 5, 1936).

**Glassworking machine.** Jakob Dichter. U. S. 2,077,827, April 20, 1937 (Feb. 6, 1936).

**Hardening perforated glassware.** Pilkington Bros., Ltd. Ger. 631,041, June 11, 1936; Cl. 32*a*. 30; *Chem. Abs.*, **30**, 6154 (1936).

**Intermediate glasses for sealing conductors into quartz vessels.** General Electric Co., Ltd. (Patent-Treuhand-Ges. für Elektrische Glühlampen). Brit. 463,889, April 21, 1937 (Jan. 24, 1936).

**Leer loader.** W. H. Failinger (Hazel-Atlas Glass Co.). U. S. 2,077,830, April 20, 1937 (April 24, 1936).

**Leer stacking or feeding mechanism.** E. P. Dorman. (United Glass Bottle Manufacturers, Ltd.). U. S. 2,080,858, May 18, 1937 (Nov. 13, 1935).

**Machine for the manufacture of glass articles.** T. F. Pearson. Brit. 463,547, April 14, 1937 (Sept. 23, 1935).

**Manufacture of hardened or tempered glass plates.** Raymond Magnien (Soc. Assurex "Le Roi des Verres de Sécurité" Magnien, Monnier & Cie) and L. A. E. Petit. U. S. 2,080,083, May 11, 1937 (May 22, 1935). An apparatus for the nonisotropic hardening of glass plates comprises a casing having one of its walls parallel to and spaced from one surface of the glass plate to be hardened, a pressure chamber and a suction chamber in the casing, a series of nozzles extending from the pressure chamber to the outer surface of the wall and arranged along the sides of contiguous regular polygons, and a second series of nozzles extending from the suction chamber to the surface, these suction nozzles being of larger cross-section that the pressure nozzles and arranged each at the center of one of the polygons.

**Method and apparatus for:**

**Making glass.** G. E. Howard (Hartford-Empire Co.). U. S. 2,079,555, May 4, 1937 (Nov. 23, 1935).

**Melting.** S. A. Forter (Hartford-Empire Co.). U. S. 2,078,794, April 27, 1937 (July 2, 1932). U. S. 2,078,795, April 27, 1937 (Sept. 6, 1932; renewed Oct. 13, 1936).

**Molding glass tubing.** Marcello Pirani and Adolf Fehse (General Electric Co.). U. S. 2,080,899, May 18, 1937 (May 4, 1932).

**Producing sheet glass.** J. L. Drake (Libbey-Owens-Ford Glass Co.). U. S. 2,077,377, April 20, 1937 (May 24, 1934).

**Method of forming hollow glassware.** L. G. Bates (Hartford-Empire Co.). U. S. 2,078,919, April 27, 1937 (Jan. 20, 1936).

**Mirror.** Gashô Tanimoto. Japan. 110,936, May 29, 1935; *Chem. Abs.*, **30**, 2340 (1936).—$SnCl_2$ solution is painted on a glass, on which a solution containing $AgNO_3$ (containing a small amount of $NH_4OH$), KOH, tartaric acid, and a saccharin (these compounds are exposed to sunlight or ultra-violet rays before mixing) is painted, and then a mixture of HCHO solution of $CuSO_4$ and NaOH solution is applied. By this process a mirror is quickly and easily made and the silver film produced is resistant to heat and moisture.

**Process for making safety glass.** B. J. Dennison (Pittsburgh Plate Glass Co.). U. S. 2,079,701, May 11, 1937 (Feb. 25, 1936). A process of laminating sheets of glass with a sheet of resin containing an amount of plasticizer which renders the sheet relatively soft and flexible at room temperatures but nonadherent to the glass sheets at such temperatures consists in first cooling the resin sheet to a temperature below room temperatures to stiffen and harden it and to facilitate the matching of the assembly and avoid the entrapping of air therein, placing the resin sheet between a pair of glass sheets, and completing the lamination by applying heat and pressure to the assembly to cause the resin sheet to adhere to the glass sheets.

**Process for the mechanical production of glass felt.** Piero Modigliani. U. S. 2,081,060, May 18, 1937 (March 7, 1936).

**Process for tempering glass.** Robert Monnier (Soc. Assurex "Le Roi des Verres de Sécurité" Magnien, Monnier & Cie) and L. A. E. Petit. U. S. 2,078,541, April 27, 1937 (Jan. 9, 1935). In the tempering of glass plates by means of movable air jets, the method consists in displacing air jets grouped in equilateral triangular formation relatively to the glass plate so that the jets sweep the surface of the glass along predetermined paths and cool it more intensively along zones disposed according to the sides of adjacent equilateral triangles and corresponding to the paths than in the areas included by the triangles between the zones.

**Quartz glass products.** Chû Onoda, Rokutarô Kawamura, Minoru Kiyono, and Ryûichi Sano. Japan. 110,943, May 29, 1935; *Chem. Abs.*, **30**, 2340 (1936).—Crude $SiO_2$ is boiled with a strong mineral acid and heated at 400 to 1000° to remove gases. The product is powdered, mixed with a binder (such as Na or K silicate), and molded. After drying, strong heat is applied to complete the process.

**Roller system for straightening glass tubes or rods.** Glaswerke Ruhr A.-G. Ger. 631,311, June 18, 1936; Cl. 32*a*. 27; *Chem. Abs.*, **30**, 6155 (1936).

**Tempering glass.** H. Perry and A. W. Grotefeld. Brit. 463,678, April 14, 1937 (Sept. 30, 1935).

**Tempering glass plate.** L. J.-B. Forbes (Pilkington Bros., Ltd.). Can. 359,279, July 21, 1936; *Chem. Abs.*, **30**, 6154 (1936).—Structural details are described of an apparatus for holding a glass plate by its edges so that any pressure applied edgewise does not buckle the plate and all parts of the plate are exposed to the tempering process.

**Transparent phosphate glass.** Paul Huppert and Hans Wolff (I. G. Farbenindustrie A.-G.). U. S. 2,077,481, April 20, 1937 (July 18, 1934). Transparent phosphate glasses having an excellent permeability to ultra-violet light similar to that of quartz and being almost completely free from solarization obtained by the addition of ammonium phosphate to the usual batches of transparent phosphate glasses.

**Wall of glass tanks.** J. H. McKelvey and J. W. Rogers (Laclede-Christy Clay Products Co.). U. S. 2,077,705, April 20, 1937 (Nov. 4, 1935); continuation of applications Serial No. 631,166, Aug. 31, 1932, and Serial No. 36,630, Aug. 15, 1935.

## Structural Clay Products

**Influence of electrolytes.** K. A. Nokhratyan, M. I. Lapovok, and B. M. Grissik. *Stroitel. Materialy*, No. 8–9, pp. 3–11; No. 10, pp. 3–17 (1936).—The introduction of a small amount of electrolytes accelerates the drying of green brick. P.B. & E.S.

**Obtaining frothed clay blocks.** Ya. M. Khananov

AND A. A. TOPORKOVA. *Stroitel. Materialy*, No. 10, pp. 31–34 (1936).—Froth is formed with the aid of a soap root. See "Thermo-insulating—," *Ceram. Abs.*, **16** [1] 20 (1937). P.B. & E.S.

**Particle size of coal used in the manufacture of porous brick.** W. KAUFMANN. *Ziegelwelt*, **67**, 11–13 (1936); *Chem. Abs.*, **30**, 3957 (1936).

**Reinforced brickwork.** ANON. *Brit. Clayworker*, **46** [540] 6–8 (1937).—Various types of brick structures using steel reinforcing, such as kilns, houses, storage bins, swimming pools, etc., are reviewed. Illustrated. See *Ceram. Abs.*, **16** [5] 150 (1937). R.A.H.

**Temperatures within and beneath a brick pavement.** H. Z. SCHOFIELD. *Bull. Amer. Ceram. Soc.*, **16** [5] 201–202 (1937).

**Thermal balance of an autoclave for vapor-treating silicate brick.** A. V. VOLZHENSKIĬ. *Stroitel. Materialy*, No. 10, pp. 17–24 (1936); see "Production—," *Ceram. Abs.*, **15** [5] 154 (1936); "Phenomena—," *ibid.*, **16** [1] 19 (1937). P.B. & E.S.

**Wire mesh gives clay-tile partition greater lateral strength.** CHAS. H. FORK. *Brick & Clay Record*, **90** [3] 154–55 (1937).—To determine the effectiveness of lightweight wire mesh embedded in the plaster to resist bending stresses, a low-cost nonbearing partition was laid up in the usual manner, using 3-cell, 6-inch tile. Units were laid with the cells horizontal except for the closure units. A light mesh was closely wired to each face of the wall, and sufficient plaster was applied to cover the mesh. Loading a clear span of 6 ft. to determine the failure due to bending stresses showed an ultimate load of 8.3 times the calculated safe load for the panel. Data on tests of sound resistance of clay-tile partitions are also given. E.J.V.

BOOK

**Efflorescences of Salts** (Der Ausblühen der Salze). KARL SCHULTZE. Theodor Steinkopff, Leipzig, 1936. 36 illustrations. Price 4.00 Rm. Reviewed in *Sprechsaal*, **70** [4] 54 (1937).—Efflorescences are known phenomena appearing in many forms and having different names and origins. S. discusses in detail the origin of efflorescences, their appearance on buildings, their mechanics, and the various theories explaining them, especially the capillary theory. These subjects are of special interest to ceramists. M.V.C.

## Refractories

**Action of water-vapor on silica brick at high temperatures and its possible industrial significance.** A. E. DODD. *Trans. Ceram. Soc.*, **35** [5] 223–46 (1936).—The action of water-vapor on nine representative brands of silica brick from Great Britain and Germany was studied by suspending test pieces, elliptical in cross-section, in a Hirsh-type furnace. The temperature was increased to 1500 to 1600°C in 3 hr. and maintained until failure. It was observed that high iron and low lime contents tended to accelerate failure which was attributed in each case either to viscous flow caused by a lowering of the viscosity of the bond or to disintegration promoted by the volatilization of silica. The decomposition at high temperatures of the bond in the silica roof brick of an open hearth fired with coke-oven gas is set forth as contributing to its abnormal failure in two weeks. R.H.H.P., JR.

**Apparatus for investigating the corrosive action of slags upon refractory materials.** A. E. J. VICKERS AND R. A. BELL. *Jour. Soc. Glass Tech.*, **19**, 151–55 (1935).—An apparatus for determining the resistance of refractory materials to the action of slags at high temperatures is described. It consists of a circular furnace built up of the materials under test; the furnace is heated by a rotating blowpipe and fed with gas and air under pressure. The slag is injected through the blowpipe flame.

**Barium aluminum silicates as refractories and their use for different technical purposes.** FELIX SINGER. *Trans. Ceram. Soc.*, **35** [9] 389–400 (1936).—The properties and characteristics of barium-anorthite fire brick manufactured from mixtures of barium carbonate and clays low in free silica are described. The brick have found some application as refractory materials for aluminum melting furnaces and crucibles and linings for salt-glaze stoneware kilns. R.H.H.P., JR.

**Behavior of cupola refractories under severe conditions.** J. LOWE. *Trans. Amer. Foundrymen's Assn.*, **7** [5] 236–47 (1936).—Much information has been acquired recently as to melting, but little has been written about cupola refractories. L. concludes that (1) length of heat rather than tonnage per hour determines how badly a cupola will burn; (2) water should not be put on the cupola lining; (3) allowing the cupola to cool by natural draft will materially increase the life of the refractory; (4) a new lining should be thoroughly dried before being put into operation; and (5) the cupola should be brought up to heat slowly. He also states that operating conditions considered severe today may be considered normal in the future. H.E.S.

**Characteristics of fire clay with special reference to manufacturing difficulties.** C. A. G. THOMAS AND J. R. ADDERLEY. *Jour. Soc. Glass Tech.*, **19**, 139–50 (1935).—The characteristics considered are iron content, plasticity, shrinkage, and porosity. Two samples of fire clay were treated by an electromagnetic method which removed accidental iron but did not lower the total iron content of the raw clay by more than 0.15%. Blunging the lump clay and then sieving without grinding did not effect any separation of iron which was evenly distributed throughout residue and fines. Plasticity can not be given to a nonplastic clay by weathering; it is an inherent property of the raw clay and is often in inverse ratio to the depth of the seam below the surface. Shrinkage and porosity are closely related properties. Clay seams having irregular shrinkages can be utilized only in small quantities admixed with other clays or as a grog material.

**Copper refinery furnace firing and refractories.** H. C. ROBSON. *Bull. Inst. Mining & Met.*, No. 373, 8 pp.; No. 374, pp. 1–15 (1935); No. 376, pp. 25–29 (1936); *Chem. Abs.*, **30**, 5913 (1936); see *Ceram. Abs.*, **15** [2] 63 (1936).

**Dry pressing in the refractory-grog industry.** P. P. KUZMENKO. *Trudy Vsesoyuz. Mendeleev. S'ezda, 1932*, **2** [1] 466–72 (1935); *Brit. Chem. Abs.-B*, **56**, 139 (1937).—Results are given on the production of grog ware by the

dry-pressing method with Boyd presses, using Chasov-Yar clays. See *Ceram. Abs.*, **12** [3] 112 (1933).

**Electrochemical production of aluminium oxide from aqueous aluminium sulfate.** V. A. PLOTNIKOV, D. P. ZOSIMOVICH, O. K. KUDRA, AND I. M. PODORVAN. *Zhur. Khim. Prom.*, **12** [3] 271-76 (1935).—In the electrolysis of aqueous $Al_2(SO_4)_3$ solutions in a bath with a diaphragm, $Al(OH)_3$ and H are evolved in the cathode space and $H_2SO_4$ and O in the anode space. In the case of pure $Al_2(SO_4)_3$, the voltage on the clamps of the bath increases toward the end of the electrolysis from 7 to 36 v. The current output attains 69%. If alkaline sulfates are added to the solution, the voltage falls and the output increases to 100%. The $p_H$ of the alum solution in the cathode space increases and falls abruptly when the process comes to an end. To obtain a good output, the anodic space must be great and the cathodic space small. The density of the current has no effect on the output; the concentration of the current increases it. The temperature increase lowers the output when the current falls. The output grows when the electrolyte is stirred. An addition of 1% of ammonium sulfate increases the output over theory and lowers considerably the $SO_3$ content of the hydroxide precipitate. The increase of the $H_2SO_4$ concentration in the anodic space over 5% gives no output, if only one diaphragm is used. A theoretical $Al_2O_3$ output and 12% $H_2SO_4$ with a 65% output are obtained with two diaphragms. By a prolonged electrolysis, the concentration of $H_2SO_4$ can be increased to 23% with an output of 42%.
P.B. & E.S.

**Foundry refractories.** J. D. SULLIVAN. *Trans. Amer. Foundrymen's Assn.*, **7** [5] 254–88 (1936).—A chart and a discussion are included. See *Jour. Amer. Ceram. Soc.*, **19** [8] 213–33 (1936). H.E.S.

**French refractory products in metallurgy.** A. C. *Rev. Matériaux Construction Trav. Publics*, No. 329, p. 30B (1937).—The properties of characteristic types of silica products and silicoaluminous and special refractories manufactured in France are given to show the high quality of French products. M.V.C.

**Glass and sillimanite.** R. LEDUC. *Rev. Matériaux Construction Trav. Publics*, No. 329, pp. 30–31B (1937).—Refractories in contact with glass in pot and tank furnaces have the power to resist the attack of the batch in accordance with the extent to which their composition approaches that of sillimanite; the ratio of 3 parts sillimanite to 1 part clay gives good results. Fired sillimanite products, having a lower porosity than products with fired refractory clay base, resist the attack of the fused mass better. Shorter drying time and greater resistance to temperature change and compression are advantages of products with sillimanite base over those with refractory clay base. M.V.C.

**Heat transmission through bare and insulated furnace walls.** R. H. HEILMAN. *Trans. Amer. Inst. Chem. Engrs.*, **31**, 165–91 (1935).—Successful utilization of insulation on high-temperature furnaces requires intelligent design and controlled firing. Perhaps the most important item in preventing breakdown of both refractory and insulation is the temperature at their junction. This temperature should be established as accurately as possible and the insulation thickness determined so that the maximum is not exceeded even when the brickwork has been eroded thin. This intermediate temperature depends mainly on (1) rate of heat flow from the maximum flame temperature to the walls, (2) emissivity of the walls, (3) thermal conductivity of the refractories, (4) thermal conductivity of the insulation, and (5) heat transfer from the outer surface to the surrounding air. Formulas and data are given for each of these. More accurate calculations will be made possible by additional accurate data on conductivity values for the various types of refractory materials, on radiant heat transfer from various flames, and on emissivity of refractories at high temperatures. See *Ceram. Abs.*, **13** [6] 153 (1934). A.P.

**Hot-patching: I, Preliminary experiments on the application of certain cements.** F. H. CLEWS, H. BOOTH, AND A. T. GREEN. *Bull. Brit. Refrac. Research Assn.*, No. 28 (Aug., 1932); reprinted in *Trans. Ceram. Soc.*, **35** [5] 257–69 (1936).—Flaking, slag erosion, and "holing" in joints are common troubles in gas retorts, and hot patching cements, whether applied by means of a paddle, by spraying, or with a cement gun, must show good adherence to the retort surface and refractoriness. The addition of a small amount of cellulose liquor and of glycerol to the mixing water improves the "stickability" of a wet cement to a hot brick surface, but the addition of fluxing agents was found to be impractical. A method is described for applying cements in the dry state to a hot surface by introduction into a stream of compressed air or into a blowpipe flame. See *Ceram. Abs.*, **16** [4] 119 (1937).
R.H.H.P., JR.

**Influence of degree of vacuum and time of soaking on determination of apparent porosity and true specific gravity.** H. OLIVER AND K. M. ROBERTS. *Trans. Ceram. Soc.*, **35** [7] 337–54 (1936).—It is shown from work on the determination of apparent specific gravity and the apparent porosity of silica and alumina refractories, facing brick, and facing tile that accurate results are obtained only when a high vacuum is employed and that the degree of vacuum is of greater importance than the soaking time. In the determination of true specific gravities, stirring has been found helpful. The authors suggest that degree of vacuum and soaking time be stated in all standard specifications for tests. R.H.H.P., JR.

**Luting compound for use at high temperatures.** V. G. ZHIVOV. *Zavodskaya Lab.*, **4** [4] 461 (1935).—The lute has a composition of about 50% $Al_2O_3$, 25% MgO, and 25% kaolin mixed to the consistency of a stiff paste with a small amount of soluble glass. Instead of MgO, pulverized magnetite brick can be used. The lute has a high refractoriness, is impermeable to gases, and is sufficiently resistant to chemical influence (especially of chlorine). A lute containing no kaolin and mixed with water can be used for coating the winding of platinum and nichrome furnaces.
P.B. & E.S.

**Magnesite brick with a small addition of iron chromite.** V. V. BELOVODSKIĬ AND TAZITDINOV. *Ogneupory*, **3** [6] 419–21 (1935). P.B. & E.S.

**Manufacture and use of insulating fire brick in the United States.** F. H. NORTON. *Trans. Ceram. Soc.*, **35** [7] 301–17 (1936).—Increased demand resulting from remarkable fuel savings in intermittent furnaces has led to the rapid development of the insulating fire brick in this

country during the last five years. Methods of manufacture, means of classification, significant properties, and possible limitations in industrial applications of this type of refractory are discussed. Of primary value is its low heat capacity which allows a furnace to be heated quickly with increased temperature and greater efficiency of combustion. Material changes in furnace design have been made with the introduction of sectionally supported walls. R.H.H.P., Jr.

**Overcoming spout trouble by use of a monolithic trough tile.** J. A. Bowers and C. Green. *Trans. Amer. Foundrymen's Assn.*, **7** [5] 248–53 (1936).—Certain difficulties encountered in a peculiar arrangement of a hot metal trough were overcome by the use of a specially designed trough tile. Tests were made on the refractory material until a composition giving the desired properties was secured. A comparison of costs entailed by the old and new methods shows a decided saving in material and labor by the use of a special tile. H.E.S.

**Recovery of alumina and fertilizers from Chinese alunite: III, Influence of ignition on the solubility of the alunite.** G. Hohorst, H. H. Wang, and T. Y. Chang. *Jour. Chem. Eng. China*, **3**, 340–47 (1936); *Brit. Chem. Abs.-B*, **56**, 236 (1937).—Chinese alunite is of low grade, containing about 50% of $Fe_2O_3$ and silicates. The $Al_2O_3$ and $K_2SO_4$ are practically all soluble in 5*N* NaOH at 80° without previous ignition. The soluble $Al_2O_3$ contains 6% of $SiO_2$ but can be freed from $Fe_2O_3$ by dilution. Solubility of $Al_2O_3$ in NaOH rises slightly with ignition up to 580° and then quickly falls. The unignited mineral is scarcely soluble in 5*N* $H_2SO_4$. Ignition to 530 to 580° renders 96% of the $Al_2O_3$ and 70 to 80% of the $K_2O$ soluble, but in this case the $Al_2O_3$ is contaminated with $Fe_2O_3$. Ignition at 800° renders the $Al_2O_3$ almost insoluble.

**Sardinian grog.** G. Ribet. *Ind. Meccan.*, **18**, 702–705 (1936); abstracted in *Chem. Zentr.*, **1937**, **i**, 3042.—The physical, mechanical, and chemical properties of grog obtained from Sardinian clays, its behavior in practical operation, and its use instead of non-Italian raw materials are discussed in detail. M.V.C.

**Silica refractories; their production and properties.** W. J. Rees. *Iron & Coal Trades Rev.*, **134** [3606] 663 (1937).—When manufacturing silica brick, a change from quartz to tridymite or cristobalite occurs; which of the two is formed depends on the presence of materials other than silica. With pure material, a change to cristobalite takes place on heating; if impurities are present in the material or get into it, tridymite is also formed. These conditions, as they are affected by temperature, are discussed in detail. If silica brick are fired thoroughly, no quartz is present; the silica is present as tridymite or cristobalite, and they have a glassy matrix, the lime-alumina-silicate, which must be cooled slowly and uniformly, particularly in the range 300° to 200°C. British and American practices are compared briefly. M.H.

**Simplified determination of specific gravity.** A. I. Sharfshtein. *Ogneupory*, **3** [7] 511–15 (1935).—The usual method of boiling is not quite satisfactory and takes much time. In this method, pulverized silica brick is mixed in hot water for 1 min. and then heated to 90 to 95° for 10 min. The whole determination takes 20 to 25 min. P.B. & E.S.

**Types of magnesite refractories for lining cement kilns.** H. G. Schurecht. *Brick & Clay Record*, **90** [3] 174–76 (1937).—Special magnesite brick have been developed with high resistance to spalling. Magnesite brick with 2 to 6% $Al_2O_3$ and 20 to 40% chrome and pure magnesite brick made with fused magnesite and magnesium hydrate have given promising results in cement kilns. Although magnesite brick are poor insulators of heat at room temperatures they are as good as other refractories at working temperatures. Silica and alumina are acid to Portland cement clinker and therefore are strongly attacked, whereas magnesite brick are not corroded by such clinkers. Tests in practice have demonstrated that magnesite refractories are much more economical to use than are 70% alumina refractories. E.J.V.

**Unfired magnesite brick, a new material for cement kiln linings.** Anon. *Tsement*, **4** [11] 17–21 (1936).—Plant experimental data furnished by C. H. Sonntag are reviewed. See *Ceram. Abs.*, **15** [3] 95 (1936). P.B. & E.S.

**Zone formation in silica brick.** F. Roll. *Ber. Deut. Keram. Ges.*, **17** [9] 437–43 (1936).—In silica brick taken from the arches of metallurgical furnaces there is usually a well-marked zone formation. These zones vary distinctly in color, physical and structural properties, and chemical composition. Using brick taken from the arch of a steel furnace that had been through about 500 runs, analyses were made on the different zones. On tabulating the results and plotting them in graphs, it was found that in all cases the minimum silica content and the maximum CaO content lie in the same zones. In the gray zones near the hot end of the brick, the iron is usually present in the bivalent form, which also predominates in the light yellow and light brown zones; in the brown zones, and especially in the dark brown zones, it is always in the trivalent form, with silica at a minimum. The results indicate that at first the brick are protected to some extent from the attack of hot gases by a considerable increase in the silica content, but later on, as the brick get shorter and shorter, this increase falls off and the content of the other oxides ($Fe_2O_3$, $Al_2O_3$, CaO, MgO, etc.) increases. E.J.V.

BULLETINS

**Cooling tank blocks.** O. Bartsch. *Fachausschussber.* (Deut. Glastech. Ges.), No. 2, 12 pp. (Nov., 1925).—B. deals with the following topics: (1) alteration of tank blocks by physicochemical reactions and by convection currents of the metal, (2) insulation *vs.* cooling, (3) theoretical considerations on heat, (4) American practice of tank-block cooling, (5) types of cooling methods, (6) influence of tank design, and (7) data for proposed computations. Examples are given. See *Ceram. Abs.*, **13** [4] 86 (1934). R.W.D.

**Federal Specification for Brick: Fire Clay HH-B-671*b*.** Anon. 5 pp. (Effective not later than Aug. 1, 1937.) Price 5¢ from Supt. of Documents, Govt. Printing Office, Washington, D. C. This specification represents a revision of Federal Specification HH-B-671*a*. The important additions are brick intended for back-up duty and those for super duty. The specifications require a minimum P.C.E. of 26 and compressive strength not less than 3000 lb./in.$^2$ for the former class and a P.C.E. of 33, a

maximum contraction of 1.0% after reheating the brick at 1600°C, and 18 cycles in the thermal-shock test after heating at 1450°C for the latter class. R.A.H.

**Manufacture of silicon carbide retorts.** E. J. Bruderlin. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 734, 6 pp. (1936); *Brit. Chem. Abs.-B*, **55** [47] 1094 (1936).—The manufacture of retorts for distillation of Zn made with clay and SiC is described.

**Preparation and properties of so-called "beta alumina."** R. R. Ridgway, A. A. Klein, and W. J. O'Leary. *Electrochem. Soc. Preprint*, 70—9, 16 pp. (1936).—A complete review of the literature concerning the supposedly "allotropic modification" of fused alumina known as "beta" is given. The results of experiments with Bayer and "dry-ore process" alumina are quoted to show the definite relation which exists between the alkali content of the fusion and the amount of "beta" produced. Evidence is adduced to indicate that "beta" is not an allotropic modification of alumina but is an alkali aluminate tentatively assumed to be composed of 1 mole of alkali oxide to 12 moles of aluminum oxide. Both a sodium and a potassium aluminate of compositions $Na_2O{\cdot}12Al_2O_3$ and $K_2O{\cdot}12Al_2O_3$, respectively, have been prepared and described.

**Sensitivity to heat of refractory materials.** K. Endell and W. Steger. *Fachausschussber.* (Deut. Glastech. Ges.), No. 2, 17 pp. (Nov., 1925).—The development of mechanical glass-manufacturing processes demands for glass-tank furnaces a higher melting capacity, greater daily output, and longer life. Insulation of tank blocks produces a more uniform heat distribution in the furnace, and this permits melting the batch and refining the metal at a lower temperature; because of the lower temperature gradient in the molten glass, convection currents are considerably reduced. Both of these considerations are beneficial as far as the wear of the refractory material is concerned. By cooling tank blocks, the layer of aluminous glass which forms against the inside face of the block becomes very viscous, tends to stick to the block, and protects it. Best results were obtained with the latter method in experiments carried out on thin test pieces of high-grade refractories. See *Ceram. Abs.*, **5** [12] 409 (1926). R.W.D.

PATENTS

**Cast refractory and method of making.** R. C. Benner and G. J. Easter (Carborundum Co.). U. S. 2,079,101, May 4, 1937 (Nov. 22, 1935). The method of making refractory shapes comprises providing a mold with molten nonmetallic refractory material which crystallizes in crystals having major and minor axes, and cooling faces of the mold at differential rates and thereby causing solidification with the crystals preponderantly oriented with the same crystal axis in a single direction inwardly of the casting from the most rapidly cooled face.

**Ceramic-bonded silicon carbide refractory.** G. J. Easter, Charles McMullen, and I. M. Logan (Carborundum Co.). U. S. 2,079,110, May 4, 1937 (Oct. 17, 1933). A silicon carbide refractory comprises silicon carbide grain and an added bond, the bond comprising feldspar and constituting less than 2% of the batch by weight.

**Chrome-ore refractories.** F. A. Harvey and R. E. Birch (Harbison-Walker Refractories Co.). U. S. 2,077,796, April 20, 1937 (July 16, 1935). Can. 359,250, July 21, 1936. A refractory comprises more than about 50% of chrome ore, at least about 10% of olivine, and magnesite in amounts from 1/4 to 4 times that of the olivine.

**Grinding material.** Carl Krug. Ger. 628,936, April 18, 1936; Cl. 80*b*. 11; *Chem. Abs.*, **30**, 5842 (1936).—The grinding material, of a porous or granular character, is obtained by subjecting a thin spray of fused $Al_2O_3$ to a high-velocity air or gas-vapor current.

**Heat-exchange apparatus.** C. F. Rosenblad. Swed. 85,142, Dec. 31, 1935; *Chem. Abs.*, **30**, 5842 (1936).—The thickness of the spiral walls of the apparatus decreases gradually or in stages from the periphery to the center.

**Heat-exchange apparatus.** C. F. Rosenblad. Swed. 85,876, March 24, 1936; *Chem. Abs.*, **30**, 5842 (1936).—Details of construction are given.

**Manufacture of fine tubes of alumina, etc.** General Electric Co., Ltd., and J. Richards. Brit. 463,430, April 14, 1937 (Sept. 27, 1935).

**Manufacture of refractory articles.** A. P. Thurston (Babcock & Wilcox Co.). Brit. 463,516, April 14, 1937 (May 15, 1936).

**Manufacture of refractory ware.** Silika- und Schamotte-Fabriken Martin & Pagenstecher Akt.-Ges. Brit. 464,204, April 28, 1937 (Jan. 21, 1935).

**Process and batch for making ceramic bodies.** G. R. Pole (Pittsburgh Plate Glass Co.). U. S. 2,079,715, May 11, 1937 (May 9, 1933). A batch mixture for a ceramic body which is highly resistant to molten glass attack comprises a dense fired homogeneous mullite grog made from a raw mineral of the sillimanite group, having a high expansion on firing and fine enough to pass through a sieve of about 100-mesh, a dense firing refractory clay, and a raw bonding material for the grog of substantially the same physical and chemical composition as the material from which the grog is made.

**Process for the manufacture of chromium ore-containing brick.** Fritz Hartmann (Magnesital Ges. mit beschrankter Haftung). U. S. 2,079,066, May 4, 1937 (June 21, 1934); continuation of application Serial No. 484,940, Sept. 27, 1930. The process for manufacturing highly refractory brick consists in sintering magnesium oxide-containing material at a temperature of at least 1600°C, mixing the sintered material together with chromium ore in such proportion as to cause the resulting mixture to contain from 80 to 10 parts of magnesium oxide and from 20 to 90 parts of chromium ore, pressing the mixture thus obtained, and drying and firing the mixture into brick of the desired shape.

**Process for the manufacture of silica brick, etc.** H. Koppers Industrieele Mij. N. V. Brit. 463,949, April 21, 1937 (Oct. 3, 1934).

**Refractories.** F. A. Harvey and R. E. Birch (Harbison-Walker Refractories Co.). U. S. 2,077,794, April 20, 1937 (June 4, 1935). A refractory material comprises about 5 to 50% of olivine of high magnesium orthosilicate content and the remainder substantially all chrome ore.

**Refractories.** F. A. Harvey and R. E. Birch (Harbison-Walker Refractories Co.). U. S. 2,077,795, April 20, 1937 (June 13, 1935). The method of making forsterite refractory of improved character comprises the steps of

grinding forsterite material to provide coarse granules, and mixing therewith magnesia-rich material containing from about 3 to about 30% of lime in an amount sufficient to provide at least about 0.8% and not to exceed about 6% of lime.

**Refractories.** Procédés et Produits Chimiques. Fr. 794,346, Feb. 13, 1936; *Chem. Abs.*, **30**, 4641 (1936).—Refractories which do not crack under very sudden changes of temperature and which have a high mechanical resistance are made by agglomerating MgO, fritted at a high temperature, of determined granulometric composition, by means of a small amount of specially activated MgO (the hydration of which produces a rise of temperature comparable to the slaking of CaO) and firing. The final firing may be effected during utilization.

**Refractory brick walls and roofs for furnaces.** M. H. Detrick Co. Fr. 790,456, Nov. 21, 1935; *Chem. Abs.*, **30**, 3193 (1936).

**Refractory heat insulation.** Frank Christenson and H. N. Clark. U. S. 2,078,753, April 27, 1937 (Aug. 22, 1936). A heat-insulating wall comprises a blanket of insulating material having a facing of castable monolithic refractory cement, the blanket comprising a layer of fibrous heat-insulating material supported between metal screens.

**Refractory material.** M. L. Buikhovskiĭ. Russ. 40,-230, Nov. 30, 1934; *Chem. Abs.*, **30**, 3959 (1936).—A mixture of $Al_2O_3$ with 1 to 3% each of talc, marble, and clay is fired at 1600 to 1670°.

**Refractory material.** Victor M. Goldschmidt. Ger. 631,010, June 10, 1936; Cl. 80*b*. 8.08; *Chem. Abs.*, **30**, 6156 (1936). Addition to 605,371 (*Ceram. Abs.*, **14** [6] 143 (1935)).—The process of Ger. 605,371 is modified in that (1) the proportion of MgO or like Mg compound is increased sufficiently to convert the Fe compounds in the ferruginous mineral material into Mg ferrite and also to convert any free or liberated $SiO_2$ and any Mg metasilicate into Mg orthosilicate; the final products may contain free MgO; (2) a compound of Fe, Cr, or Al may be added to the mixture; and (3) about 2% of a catalyst or crystallization promoter, *e.g.*, NaCl, may also be added. Specific compositions are described.

**Refractory mortar composition.** F. A. Harvey and R. E. Birch (Harbison-Walker Refractories Co.). U. S. 2,077,793, April 20, 1937 (Nov. 24, 1934). A refractory mortar containing a major proportion of olivine and a minor proportion of bonding material comprising an admixture of colemanite, sodium silicate, kaolin, and flint, and characterized by resistance to reaction in contact with silica, chrome, magnesia, and alumina refractories at high temperatures.

**Refractory products.** Non-Metallic Minerals, Inc. Brit. 464,047, April 21, 1937 (Dec. 29, 1934).

## Terra Cotta

**Engobing, glazing, and blue-smoking of roof tile.** Anon. *Belg. Netherl. Klei-Ind.*, **10**, 1–3 (1936); abstracted in *Chem. Zentr.*, **1937**, i, 2431.—A description of methods used is given. See *Ceram. Abs.*, **15** [2] 66 (1936). M.V.C.

**Measurements of swelling as a control of hair cracks.** H. Möhl. *Sprechsaal*, **70** [6] 71–73; [7] 83–85 (1937).—Fired porous ware, even completely glazed ware, shows certain swellings of the body which eventually produce hair cracks from the effect of moisture. There is also the danger of cracks due to different coefficients of thermal expansion of the glaze and body. In porous bodies this swelling is the chief cause of cracks and it must be carefully controlled in fired bodies. A suitable method is described. The possibility of lowering the swelling is important; it is determined by the color and porosity of the body and conditions of firing. M.V.C.

STANDARD

**Salt-Glazed Ware Pipes and Fittings. British Standard Specification No. 65—1937.** British Standards Inst., London. Price 2s net. This revision of the earlier specification includes (1) British standard tested salt-glazed ware pipes, every pipe being tested hydraulically, and (2) British standard salt-glazed ware pipes and fittings, only a proportion of the pipe being tested hydraulically. The chief dimensions and tolerances of pipes and fittings are specified. The pressure applied in the hydraulic test is 20 lb./sq. in., and this must be maintained for at least 5 sec. without any sign of leakage. One absorption test shall be made on every hundred pipes or fittings; the weight of water absorbed after immersion for 1 hr. in boiling water shall not exceed 6% for pipes ¾ in. thick or 10% for pipes 1½ in. thick. A.B.S.

PATENTS

**Composite vitreous tile and concrete stave.** P. C. Fish. U. S. 2,077,750, April 20, 1937 (Aug. 1, 1931; July 17, 1935). A vitreous tile and concrete stave comprises a tile base or body with molded concrete tongue and groove joint extensions.

**Glazed ceramic acoustic correction material.** Joseph R. Parsons (Canadian Gypsum Co., Ltd.). Can. 359,057, July 14, 1936; *Chem. Abs.*, **30**, 6156 (1936).—A sound-absorbing ceramic body is permeated with pores extending to its surface and glazed between the openings of the pores. A suitable glaze has a molecular composition of 0.27 $Na_2O$, 0.20 CaO, 0.11 BaO, 0.35 ZnO, 0.07 CoO, 0.45 $Al_2O_3$, and 2.75 $SiO_2$.

**Lightweight ceramic composition.** W. R. Seigle. (Johns-Manville Corp.). U. S. 2,079,665, May 11, 1937 (July 23, 1932).

**Paving construction.** A. C. Fischer. U. S. 2,077,749, April 20, 1937 (Aug. 21, 1933). A paving block having a wear-exposed surface provided with a series of recesses and tread strips containing granular material inserted within the recesses and extending above the surface of the block and projecting laterally of the recesses at the upper surface of the block.

## Whiteware

**German kaolins for manufacture of porcelain.** R. Rieke and L. Mauve. *Ber. Deut. Keram. Ges.*, **17** [11] 537–62 (1936).—Eight well-known German kaolins and one hitherto untried pitchstone kaolin were introduced, partly alone and partly mixed with Zettlitz kaolin or with Zettlitz and another German kaolin, into a hard porcelain body without changing its rational composition. The usual physical properties were determined on the unfired and fired bodies and are given in complete tabulated form. E.J.V.

**Magnesium silicates, steatite: VII.** Shoichiro Nagai and Giichi Inoue. *Jour. Japan. Ceram. Assn.*, **43**, 412–24 (1935); *Chem. Abs.*, **30**, 2338 (1936).—Adding 3 to 15% $Al_2O_3$ to talc decreased firing temperature and shrinkage and increased bending and compressive strengths; the mixtures were dry-pressed at 600 kg./sq. cm. and fire ' at 1300 to 1350° for 2 hr. The $Al_2O_3$ was added as $Al(OH)_3$. Adding 10 to 20% Zettlitz kaolin gave greatly increased strength and very low porosity; the firing temperature was 1350 to 1400°. Adding 5 to 10% ZnO gave less improvement than did kaolin. The talc-$Al_2O_3$ mixtures gave the greatest resistance to spalling when quenched in water, talc-kaolin mixtures next, and talc-ZnO mixtures least. Stability under superheated live steam at 10 atmospheres pressure and temperature about 180° in an autoclave was determined. Talc-$Al_2O_3$ and talc-kaolin samples were stable; talc-ZnO samples, especially with only 5% ZnO, were a little unstable, but all were superior to talc alone. Electrical resistance was especially high in the talc-$Al_2O_3$ series. The work is being continued. For Parts **III–VI** see *Ceram. Abs.*, **14** [9] 220 (1935).

**Ordinary unfritted lead glazes.** K. Litzov, Brigitte Jaeschke, and Ilse Friedrich. *Sprechsaal*, **70** [4] 42–46 (1937).—Experiments showed that the crust formations observed frequently in lead glazes depend not on the fact that these glazes are difficult to fuse but on their devitrification. This devitrification can be avoided by the addition of alumina, introduced as clay substance. Illustrated. M.V.C.

**Posan porcelains.** D. T. Shaw, T. C. Hsu, and S. P. Chu. *Jour. Chem. Eng. China*, **3**, 354–72 (1936); *Brit. Chem. Abs.-B*, **56**, 241 (1937).—Analyses of the clay, flint, and feldspar used in making this porcelain are given. An exhaustive series of trial mixes and firings to determine the best proportions for electrical, chemical, and ordinary porcelains is described. Glazes used in the industry, on being tested, were found to be unsatisfactory, owing to a deficiency of CaO.

**Progress report on occurrence and refining of some Tennessee Valley primary kaolins, their use in vitreous ceramic whiteware bodies, and results of experiments run to develop a modified type of vitreous translucent dinnerware made from all-American materials: I, Purpose and aims; II, Description of the laboratory.** Tennessee Valley Authority Ceramic Laboratory Staff. *Jour. Amer. Ceram. Soc.*, **20** [6] 175–77 (1937). **III, Study of primary North Carolina kaolins and laboratory experiments in refining to produce a material suitable for use in vitreous whiteware.** R. E. Gould, A. J. Hedquist, and W. B. Boyd. *Ibid.*, pp. 178–92. **IV, Development of a true porcelain or china-type vitreous dinnerware body using American materials.** R. E. Gould and A. J. Hedquist. *Ibid.*, pp. 192–96. **V, Casting all-kaolin bodies of true porcelain and china types.** A. J. Hedquist, R. E. Gould, and E. W. Wilson. *Ibid.*, pp. 197–202. **VI, Plastic forming of vitreous bodies of true porcelain or china type, using American kaolins as plastic constituents, with notes on a new method of manufacturing straight flat ware.** R. E. Gould. *Ibid.*, pp. 202–206. **VII, Experimental electrical firing of true porcelain and china-type bodies made from American materials for the determination of suitable schedule.** R. E. Gould and A. J. Hedquist. *Ibid.*, pp. 207–14.

**Replacement of Cornwall stone by talc and feldspar in a wall-tile body.** H. Z. Schofield. *Bull. Amer. Ceram. Soc.*, **16** [5] 203-204 (1937).

**Spark plugs; their manufacture on a small scale.** A. G. Arend. *Electrician*, **118** [3] 63 (1937).—A. describes in detail the manufacture of spark plugs from gunmetal cases and asbestos cement insulators. The method is apparently meant for amateurs or for experimental use. H.K.R.

**Spitting of glazes in the enamel kiln: II.** J. W. Mellor. *Trans. Ceram. Soc.*, **35** [8] 355–63 (1936).—The antecedent events and conditions to the theory of carbon spitting described in Part I have been actually realized. The presence of carbon in a body below a spitting glaze is demonstrated by photomicrographs. The blistering of glazes discolored by smoke in the glost oven is produced by aërial oxygen diffusing into the permeable glaze and oxidizing the particles of carbon. The mechanism of the development of pale spots in colored glazes such as chrome tin pink, manganese colors, celeste-blue, and opaque tin glazes is described as the healing of scars produced by blisters into which the glaze flows more readily than the suspended pigment or stain. For Part I see *Ceram. Abs.*, **16** [1] 28 (1937). R.H.H.P., Jr.

### PATENTS

**Bidet.** Ippolito Salvoni (Riccardo Salmona and E. Q. Jackson). U. S. 2,080,438, May 18, 1937 (June 17, 1936).

**Ceramic mass.** Hermann Plauson. Ger. 629,513, May 5, 1936; Cl. 80*b*. 1.15; *Chem. Abs.*, **30**, 6155 (1936).—A porcelain-like cold-binding mass for making earthenware consists of a hydraulic binding agent and a solution of a hardening synthetic resin alone or with an addition of polymerized vinyl esters or acrylic acid esters. These esters may be replaced by analogs or homologs, by synthetic or natural waxes, or by cellulose esters. An addition of semifired kaolin, ceramic clay, transparent or colored ground glass, glass-wool powder, $SiO_2$, talcum, metal bronze, metal powder, or mica may be added. Water or an aqueous salt solution is used to mix up the above into paste for molding.

**Mica-insulated spark plug.** O. C. Rohde (Champion Spark Plug Co.). U. S. 2,080,854, May 18, 1937 (March 17, 1936). A spark plug comprises a shell having a central holding portion, a central electrode, a mica cigarette surrounding the electrode, powder compacted between the

cigarette and the holding portion of the shell, and self-sustaining insulating material surrounding the mica cigarette above and below the powder and in contact with the powder for a material distance outward from the cigarette.

**Vitreous porcelain composition and product.** J. I. BAHL (Raymond W. Loichot). U. S. 2,077,610, April 20, 1937 (Feb. 27, 1933; June 8, 1933). A composition of matter adapted for use for making vitreous porcelain products, the composition of matter including the several materials as follows, and the percentage quantities of the several materials lying substantially within the following ranges: H. P. 1 Canadian ball clay 6 to 23, feldspar 15 to 20, kaolin clay 7 to 8, china clay 17 to 32, whiting 1 to 6, and flint 38 to 40%.

## Equipment and Apparatus

**Air separation of minerals: I, Historical development.** R. R. SLAYMAKER. *Bull. Amer. Ceram. Soc.*, **16** [5] 195–200 (1937).

**Alloy for electrical heating.** J. H. RUSSELL. *Metal Ind.* [London], **49** [4] 94 (1936).—R. states that the many initial troubles encountered with the iron-aluminum-chromium-cobalt alloys (Kanthal) as a heating element have been overcome. This material can now be produced in many sizes down to as small as 0.001 in. in diameter. It also gives a longer life, maintains its load over a longer period, and resists the chemical attack due to alkalis in refractory supports better than the nickel-chromium alloys. H.E.S.

**Apparatus for electrophoretic analysis of colloidal mixtures.** ARNE TISELIUS. *Trans. Faraday Soc.*, **33** [4] 524–31 (1937).—Some improvements in the experimental arrangement for electrophoresis are discussed, with special attention to the study of mixtures. A considerable increase in the applied potential gradient can be obtained by changing the shape of the U-tube and by keeping the electrophoresis tube at a temperature near that of the density maximum for water (+4°C), thus greatly reducing the risk of heat convection currents. A modification of an earlier construction of electrophoresis apparatus is described, in which attention has been given to these points. The new apparatus also has provision for taking out samples of the separated fractions. The optical observation of the boundaries is made by an improved method depending upon refractive index. For difficult separations, large electrode vessels and a compensation arrangement can be used, making it possible to obtain a large separation volume even if the components migrate in the same direction. G.R.S.

**Ardoloy-tipped drawing dies.** ALFRED HERBERT, LTD. *Metal. Ind.* [London], **49** [10] 235 (1936).—Ardoloy, a high-speed cutting alloy, is being employed to face dies. According to the material drawn, the life of the dies is from 30 to 100 times greater than that of solid steel. They can be retaped to shape and adjusted to the required size in the die boxes. Ample lubrication and water-cooling are recommended to prolong the life of the die. Illustrated. H.E.S.

**Automatic control for currents of gas under moderately reduced pressures.** R. C. BRIMLEY. *Jour. Sci. Instruments*, **14** [3] 102–103 (1937).—A glass-tubing device containing mercury and a porous diaphragm to control the flow of moderately small amounts of gas is described. In the example cited, the device passed 200 liters/hr. at a pressure of 10 cm. of mercury above atmospheric. Illustrated. J.L.G.

**Breakdown of regenerators.** S. S. BERMAN. *Keram. & Steklo*, **10** [10] 19–28 (1934).—B. gives an analysis of the reasons for a series of breakdowns of regenerators in Russian glassworks. The breakdowns were caused chiefly by (1) unsatisfactory construction of the regenerators, (2) operating conditions, and (3) quality of the material used. Illustrated. M.V.C.

**Color measurement of opaque surfaces.** E. R. BOLTON AND K. A. WILLIAMS. *Analyst*, **62** [730] 3–10 (1937).—A spectrophotometric instrument is described by which the amount of light scattered normally from the test surface in various parts of the spectrum is expressed as a percentage of the amount of light similarly scattered from a standard white surface under the same conditions. The white standard is obtained by smoking an approximately white surface with burning magnesium. H.H.S.

**Comparison between the open and closed cycle of dry grinding in laboratory ball mills.** D. N. LIFLYAND AND A. G. TUNTZOV. *Inst. Mekhanicheskoĭ Obrabotki Poleznuikh Iskopaemuikh "Mekhanobr," 15 yr. Socialistic Ind. Service*, **1**, 256–300 (in English 300–301) (1935); *Chem. Abs.*, **30**, 2802 (1936).—Materials such as quartz or apatite were used in a series of grinding experiments to determine comparative efficiencies of open- and closed-cycle small ball mills. A charge occupying 12% of the volume of the mill gave the best results in both types, but the closed-cycle mill has a greater useful capacity than the open-cycle mill. For the same final grain size, the finished product from the open-cycle mill contains more of the overground material than that from the closed-cycle mill. Formulas are given for the yields of ground product for either type of mill.

**Comparison between the open and closed cycle of wet grinding in laboratory ball mills.** A. G. TUNTZOV. *Inst. Mekhanicheskoĭ Obrabotki Poleznuikh Iskopaemuikh "Mekhanobr," 15 yr. Socialistic Ind. Service*, **1**, 302–46 (in English 346–47) (1935); *Chem. Abs.*, **30**, 2803 (1936).—Tests made on wet-grinding of iron ore and quartz in small ball mills showed that a closed-cycle mill has twice the useful capacity of an open-cycle mill of the same size. The best yields are obtained in either case under the following conditions: rate of mill velocity 85 to 90% of critical, where the critical velocity $N = 300/\sqrt{R - r}$ mm., $R$ and $r$ being radii of ball mill and balls, respectively; ball charge 45 to 50% of the mill volume; ore charge 12% of mill volume; ratio of solid:liquid = 1:1.

**Crystal vibration pick-up.** SUNDT ENGINEERING CO. *Instruments*, **10** [4] 90 (1937).—This instrument is sufficiently sensitive to pick up extremely small vibrations, such as watch ticks, and make them audible and sufficiently rugged to withstand vibrations up to $^1/_{12}$ in. amplitude. It employs a bimorph crystal mounted inside the aluminum case and having no direct mechanical connection with the 8-in. Duralumin test prod. The apparatus is designed to

be used with a special oscilloscope with a built-in amplifier to determine the frequency, amplitude, and velocity of vibrations. Applications include production testing of electric motors, ball bearings, crankshafts, gear trains, fans, etc., locating sources of vibration in machinery, checking smoothness of surfaces, and testing sound-deadening materials. R.W.R.

**Drying in heavy ceramics.** P. THOMAS. *Ziegelwelt*, **68**, 30–32 (1937); abstracted in *Chem. Zentr.*, **1937, i**, 2845.—Fissures caused by drying can be eliminated by longer drying. Artificial drying installations are discussed. M.V.C.

**Electrical temperature measurement with special reference to boiler work.** F. J. MATTHEWS. *Brit. Clayworker*, **46** [540] 8–10 (1937).—M. discusses resistance thermometers and thermocouples and advantages and disadvantages of each type as applied to boiler operation. R.A.H.

**Experiences with high-frequency furnaces.** N. BROGLIO. *Giesserei*, **24** [4] 73–80 (1937).—The special advantages of high-frequency furnaces, *viz.*, the production of heat in the material itself and the almost complete transformation of electrical energy into heat, are explained. Modern design of furnaces, electric generators, and control equipment is described. The largest type yet built is a melting furnace for 8 tons. Consumption per ton of melted material is 550 to 600 kw. The thermal efficiency including the frequency transformer is between 60 and 75%. M.H.

**Improvements on existing machinery: II.** W. H. BATES. *Brit. Clayworker*, **45** [539] 370–72 (1937).—B. describes the method and cost of installing ball and roller bearings in grinding rollers and clutch of the drive for the rollers. The use of new and improved dry-pan plates is also described. For Part I see *Ceram. Abs.*, **16** [3] 94 (1937). R.A.H.

**Instrument for combustion control.** ELLIOT BROTHERS, LTD. *Jour. Sci. Instruments*, **14** [3] 107–109 (1937).—The instrument gives a direct reading of the wasted heat carried away by flue gases. This heat loss is also recorded on a continuous chart. The operation of the instrument is described and discussed. Illustrated with circuit diagram. J.L.G.

**Laws of the screening process.** I. M. ABRAMOVICH. *Inst. Mekhanicheskoĭ Obrabotki Poleznuikh Iskopaemuikh "Mekhanobr," 15 yr. Socialistic Ind. Service*, **1**, 367–409 (in English 409–10) (1935); *Chem. Abs.*, **30**, 2804 (1936).—The relation between time, $t$, of screening and weight, $h$, of the product passing through the screen is expressed in the form of differential equations of the type $dh/dt = ft$.

**Measuring higher temperatures.** F. TROMBE. *Documentation Sci.*, **5**, 147–51, 178–82, 209–13, 245–50 (1936); abstracted in *Chem. Zentr.*, **1937, i**, 1734.—T. gives a general review of the chief physical apparatus used for measuring temperatures up to 3000°C and higher. M.V.C.

**Mechanical handling in the pottery industry.** P. C. BLEAKMAN. *Trans. Ceram. Soc.*, **35** [7] 318–36 (1936).—The various methods of mechanical handling in use in the pottery industry include platform, tray, and bucket elevators, electrical blocks, and roller, overhead, and belt conveyers. Special attention is given to the overhead chain conveyer as the most useful type of labor-saving equipment. R.H.H.P., JR.

**Metals and alloys in chemical plant construction.** J. A. LEE. *Metal Ind.* [London], **49** [3] 55–59, 65; [4] 85–88, 95 (1936).—Developments in chemical engineering have demanded materials possessing improved strength and resistance to creep. The use of chromium-iron alloys, where resistance to oxidation, high temperatures, sulfur, and oxides of nitrogen is important, is described. Chromium-nickel-iron alloys serve a similar purpose. Copper and its alloys of zinc, tin, chromium, nickel, silicon, manganese, and beryllium offer many advantages in resisting corrosion and still maintaining high heat conductivity. The advantages of lead and its alloys are due to its combination of chemical resistance, pliability, and good working properties. Aluminium, with its wide range of alloys, combines light weight, adequate strength, and resistance to shock and corrosion. Silver has the advantage of high heat conductivity and easy fabrication by spinning, drawing, or soldering. The precious metals are also used to a limited extent owing to their high melting point and resistance to oxidation. H.E.S.

**One hundred-plate semiautomatic laboratory bubble-cap still of glass.** JOHANNES H. BRUUN AND W. B. MASON FAULCONER. *Ind. Eng. Chem., Anal. Ed.*, **9** [4] 192–94 (1937).—The still has a separating power equivalent to about 70 to 72 theoretical plates. Since the height of the fractionating column is only about 2 m. (6.5 ft.), the new still can be placed in any laboratory of average or even below average height. At low rates of distillation the still is practically self-operating. Illustrated. F.G.H.

**Plasticity diagram for clays.** J. F. HYSLOP. *Trans. Ceram. Soc.*, **35** [5] 247–56 (1936).—For a number of clays, softness-extensibility curves showing the effects of varying water content and the addition of acids and alkalis have been evaluated from penetration data obtained from the movement of a loaded plunger in a mold and are presented as a measure of plasticity or moldability. R.H.H.P., JR.

**Rationalization of air drying of building brick.** A. I. KRAMARENKO AND A. I. LYUDVINSKIĬ. *Stroitel. Materialy*, No. 11, pp. 6–10 (1936). P.B. & E.S.

**Resistance materials for electric furnaces.** C. J. SMITHELLS AND P. R. BARDELL. *Metal Ind.* [London], **49** [6] 134–38 (1936).—The materials available as resistance elements for domestic appliances and industrial furnaces are (1) nickel (60%)-chromium (15%)-iron (25%) alloys, (2) nickel (80%)-chromium (20%) alloys free from iron, (3) nickel-chromium alloys plus 1 to 5% silicon and aluminum, (4) the iron (70%)-aluminum (1.5 to 5.0%)-chromium (20 to 30%) and cobalt (2.5%) alloys known as Kanthal, (5) silicon carbide, such as Silit and Globar, and (6) molybdenum and tungsten. The essential features of a standard test are (*a*) resistance to oxidation, (*b*) resistance to corrosive atmosphere, (*c*) mechanical properties during life (creep or sag, brittleness, growth), (*d*) effect of wire diameter, (*e*) effect of repeated heating and cooling, (*f*) effect of temperature, and (*g*) changes in emissivity or resistance. The methods of testing and limitations are discussed. H.E.S.

**Segregation in clay storage bins.** J. GR. *Keram. Rundschau*, **44** [24] 282–83 (1936).—G. made small-scale

experiments on bins provided with glass walls. The square cross-section is the best. The pyramidic distributors should have reduced corners; clefts should be of variable width, those outside being narrower. F.E.V.

**Discussion.** T. W. Garve. *Brick & Clay Record*, **88** [4] 145–46 (1936).—G. points out discrepancies in the article. Segregation can be avoided by preventing formation of a cone of material when filling the bin, but conical or pyramidal distributors do not prevent segregation. To obtain an approximately uniform flow of the entire mass of grog or clay it would be necessary to have a vertical cylinder for a bin, with the outlet the full size of the cylinder. E.J.V.

**Separation of mineral mixtures in a pulsating air stream.** K. K. Liandov. *Inst. Mekhanicheskoĭ Obrabotki Poleznuikh Iskopaemuikh "Mekhanobr," 15 yr. Socialistic Ind. Service*, **1**, 481–506 (in English 506–507) (1935); *Chem. Abs.*, **30**, 2802 (1936).—The experimental work was carried out with mixtures of pure minerals, *viz.*, baritedunite, quartz-anthracite, and galena-quartz, in an ordinary pulsator of the Richards type, where an adjustable glass tube provided with a wire-cloth bottom was substituted for the cell. It was found that the time required to separate any mixture is directly proportional to the depth of the layer. For the same depth of layer, the time of separation is shorter, the greater the difference in specific gravity of the minerals to be separated. For any depth of layer, the most rapid separation corresponds to 420 pulsations per minute. Empirically, the above relationships are expressed by the formula $T = 0.7h1/d\sqrt{\delta_l/\delta_h}$, where $T$ = time of separation (sec.), $h$ = depth of layer (mm.), $d$ = arithmetical mean diameter of the particles (mm.), and $\delta_l$ and $\delta_h$ = specific gravity of light and heavy mineral, respectively.

**Small-picture photography in industry.** W. Anders. *Giesserei*, **24** [4] 80–83 (1937).—Attention is called to the advantages of small but clear pictures ($2^1/_4$ x $3^1/_2$ in.) in illustrating technical processes, special features of certain products, etc. Methods and photographic equipment are described. M.H.

**Stepping up production with feeder-temperature control.** O. P. Kossatz. *Glass Ind.*, **18** [4] 121–23 (1937).—K. discusses the background, present-day practice, and economic advantages of feeder control and recording equipment. Results obtained by their installation are classified under increased production, greater economy, and increased quality of glassware. E.J.V.

**Time factor in drying.** H. H. Macey. *Bull. Brit. Refrac. Research Assn.*, No. 30 (April, 1933); reprinted in *Trans. Ceram. Soc.*, **35** [8] 379–87 (1936).—M. suggests a method of obtaining a figure for the "time efficiency" of a drier, describes the mechanism of drying a block of clay under constant conditions, and gives formulas for estimating the times of drying before and after leather hardness is reached. It has been found that high temperatures rather than low humidities are necessary to increase the rate of drying during the last stages. R.H.H.P., Jr.

**Vacuum press in porcelain industry.** Friedrich Dettmer. *Sprechsaal*, **70** [2] 13–16 (1937).—The chief functions of vacuum presses and the homogenization and de-airing of porcelain mixes are discussed. M.V.C.

STANDARD

**Method of Measurement of Air-Flow (from Compressors). British Standard Specification No. 726—1937.** British Standards Inst., London. Price 2s net. The free air delivered in cubic feet per minute is found from the following formula:

$$\frac{KTi}{p}\sqrt{h}\sqrt{m/T},$$

where $K$ = constant for rounded nozzle, $Ti$ = temperature of intake (°A), $T$ = temperature at nozzle (°A), $p$ = absolute pressure at intake (in. Hg), $h$ = pressure drop across nozzle (in. water), and $m$ = absolute pressure at downstream side of nozzle (in. Hg). The details of the method are described and illustrated. A.B.S.

PATENTS

**Abrasive bar mill.** Asbjorn Sonsthagen. Ger. 628,978, April 20, 1936; Cl. 50*c*. 16.01; *Chem. Abs.*, **30**, 5842 (1936).

**Abrasive throwing apparatus.** American Foundry Equipment Co. Brit. 464,608, May 5, 1937 (June 21, 1935); addition to 442,539.

**Apparatus for de-airing clay and like plastic materials.** John M. Willis and Charles L. Willis. Fr. 796,319, April 4, 1936; *Chem. Abs.*, **30**, 6155 (1936).

**Apparatus for making ceramic articles.** R. E. Gould (Tennessee Valley Authority). U. S. 2,080,418, May 18, 1937 (March 9, 1936). In an apparatus for making ceramic articles, one side of the article is formed on a rotatable molding head and the other side of the article is formed by a tool having a profile complementary to $^1/_2$ the profile of the side of the vertical section of the article being formed by the tool as the head rotates.

**Apparatus for treating molten materials.** L. C. Edgar and E. E. Brosius. U. S. 2,079,111, May 4, 1937 (Dec. 15, 1931; renewed Aug. 5, 1935). An apparatus for centrifuging and granulating slag, comprising a centrifuge, is described.

**Clay-cutting devices.** R. Stagl. Brit. 463,944, April 21, 1937 (Oct. 2, 1935).

**Glazes for metallic resistors.** Ernst Hediger (Globar Corp.). Can. 358,952, July 7, 1936; *Chem. Abs.*, **30**, 6156 (1936).—A slip made of a mixture of, by weight, 80% fine SiC and 20% bentonite or a self-fluxing, relatively insulating clay with sufficient water to keep the material in suspension is applied to the surface of the molded resistor after the resistor has been fired or cured. The coated resistors retain their electrical properties better than uncoated resistors up to 1000 hr. of use and have greater mechanical strength.

**Processing of moist plastic bodies.** S. C. Lyons (Bird Machine Co.). U. S. 2,032,624, March 3, 1936 (Nov. 28, 1934). In the extrusion of a moist, plastic mass, containing fine solids tending to deposit on a positive electrode, as elongated bodies of small cross-sectional area through an extruding machine equipped with a perforated discharge plate, that practice which involves impressing the discharge plate with an electronegative charge and another part of the machine contacting with the mass with an electropositive charge under conditions to attract mois-

ture by electroösmosis to the surfaces of the plate, thereby maintaining such surfaces lubricated as the mass is being extruded, and substantially constantly freeing the positively charged part of the machine substantially completely from the solids tending to become deposited thereon by electrophoretic attraction.

**Rollers for clay-grinding and other mills.** D. Whitehouse. Brit. 463,810, April 21, 1937 (Nov. 14, 1935).

**Tube-forming machine.** H. H. Hentzell and A. M. Morris (Ohio Brass Co.). U. S. 2,048,004, July 21, 1936 (Sept. 28, 1935).

**Vibratory classifier.** E. J. Winkleman. U. S. 2,079,059, May 4, 1937 (April 12, 1934).

ERRATUM

In *Ceram. Abs.*, **16** [5] 158 (1937) the text of the patent entitled "Apparatus for cleaning articles of ceramic materials" should appear under the title "Apparatus for producing hollow brick closed on all sides." The text under this title should appear under "Apparatus for cleaning articles of ceramic materials." The names of the patentees and the patent numbers are correct as printed.

## Kilns, Furnaces, Fuels, and Combustion

**Application of protective atmospheres to the heat-treatment of metals.** A. G. Robiette. *Metal Ind.* [London], **49** [4] 79–84, 93 (1936).—With the introduction of electric heat treatment, it is found possible to introduce protective atmospheres into furnaces which were made gas-tight externally. Recent research on the application of atmospheres generated from hydrocarbons, coal, and coke-oven gas has led to the development of a gas plant which has been used successfully for bright annealing. Illustrated. H.E.S.

**Ceramic firing processes: VI.** Otto Krause and Eberhard Keetman. *Sprechsaal*, **70** [9] 114–15 (1937).—The conclusions of the study are as follows: (1) The firing temperature of not densely vitrified ware (feldspar ware and semiporcelain) affects shrinkage, porosity, and mechanical strength of the ware and hence should be regulated. Pure white color can not be obtained at prevailing temperatures. The general yellowish color tone is improved by other means. The firing temperature of densely vitrified hard and soft porcelain has less marked effect. High temperatures are necessary to develop the white color of porcelain, and they overcome the effect of atmosphere. The best ways to develop mechanical strength are by high temperatures; the length of firing is especially important. (2) The shorter the firing time, the better is the value of mechanical strength. The more fluxes and the less quartz the bodies contain, the greater the loss in mechanical properties. Low firing temperatures (1200°) require long firing to lower porosity and increase mechanical strength. These temperatures are good for firing semiporcelain only. (3) The interruption of cooling time is valuable for thick-walled ware, eliminating thermal strains. The structure of the body, *i.e.*, the ratio of crystallized to glassy constituents and their nature, does not change during cooling. An improvement of ceramic ware, in a metallographic sense, is not to be expected. (4) The effect of furnace atmosphere is great: in oxidized firing, iron (III) oxide (always present) disintegrates into iron (II) oxide at 1300° with a simultaneous splitting of oxygen; this affects porosity in densely sintered bodies. This increase in porosity is prevented by reduced firing (in Germany), as iron (III) oxide is transformed into iron (II) oxide at lower temperatures and forms an iron silicate. This fusible iron (II) silicate promotes the sintering effect of other fluxes. (5) The German method of firing hard porcelain at high temperatures for a short time and the American method of firing at lower temperatures for a long time to obtain sufficient strength have been studied. Both methods yield the same results, provided the firing is performed correctly and there is a sufficient quantity of fluxes. It was proved, however, that the high temperatures used in Germany are technically unnecessary. (6) This fact (of lowered temperature of firing) opens a wide field for the use of electric furnaces in the porcelain industry. For Part **V** see *Ceram. Abs.*, **16** [3] 96 (1937). M.V.C.

**Coke from Illinois coal. Temperature conditions in sole-flue ovens.** Gilbert Thiessen. *Ind. Eng. Chem.*, **29** [5] 506–13 (1937).—Coke has been commercially produced from Illinois fine coal in an oven in which the charge lies in a wide, shallow layer and is heated from the bottom. The temperature conditions in the charge have been determined. The plastic zone travels at a rate of 0.78 in./hr. in the lower 7 in. of the charge. The lower two-thirds of a coke made in this type of oven have the properties of a high-temperature, low-volatile coke and the upper third has the characteristics of a low-temperature coke. Such coke can be easily pushed from the oven. For domestic use, this coke has the advantage of ease of ignition. If desired, the coking process can be carried to completion to yield a product which has the characteristics of high-temperature coke throughout. The gas produced in these ovens is similar to normal coke-oven gas with the exception of lower hydrogen and methane contents. Analyses of coals coked, of coke and gas produced, and of horizontal sections of coke at various intervals from the oven floor are presented. Illustrated. F.G.H.

**Electrocalorigene resistors of electroceramic furnaces.** A. Paoloni. *Corriere Ceram.*, **18** [1] 5–11; [2] 37–45 (1937).—The extension of the application of electroceramic furnaces depends on (1) the suitability and cost of the electrocalorigene resistors, (2) thermal yield of the furnace, and (3) cost of electric energy. Metallic resistors of chrome-nickel are preferred with electrocalorigene resistors for maximum temperatures of 1100°C. For the temperature interval of 1100 to 1250°C, metallic resistors of chrome-aluminum cobalt and iron, of the Kanthal A1 type, are used. For electroceramic furnaces in which 1250 to 1400°C are reached, ceramic resistors with silicon carbide bases of the Silit or Globar type are used. From 1400° on, it is necessary to use ground graphite mixes. The most important factor to be considered in resistors is their durability. Metallic resistors yield the most heat, and research to find alloys for temperatures of 1250 to 1400°C is being carried on. The heat consumption of electric furnaces is satisfactory, especially if no saggers are used. Furnaces with double tunnels are the most recent develop-

ment; with such furnaces the consumption of electric energy is reduced to 1.5 to 2 kw.-hr./kg. of porcelain fired at 1350°C. M.V.C.

**Exchange of energy between a gas and a solid or liquid surface.** T. Alty. *Science Progress*, **31** [123] 436–48 (1937).—If a solid at one temperature is immersed in a gas at another temperature, the amount of energy exchange is not so great as theory would indicate. The ratio of actual to theoretical exchange is called the accommodation coefficient and is expressed as $\alpha$. Thus for glass as solid and hydrogen as gas, $\alpha = 0.26$. The accommodation coefficients of neutral atoms and molecules, ions, and liquids are discussed. H.H.S.

**Firing refractories in a circular tunnel kiln. First industrial use of this type of kiln in this branch of industry.** R. M. *Rev. Matériaux Construction Trav. Publics*, No. 329, pp. 25–26B (1937).—M. describes the circular tunnel kiln for firing brick and other refractory products built by the Illinois Clay Products Co., Goose Lake, Ill. M.V.C.

**Flame speeds in moist carbon monoxide-oxygen mixtures.** V. Voronkov and A. Sokolik. *Nature*, **137** [3465] 533–34 (1936).—Payman and Wheeler find a maximum speed of propagation of flame for the $2CO + O_2$ mixture, while Bone finds another, more sharply defined, at 75% CO. The authors ignited mixtures containing from 20 to 92.5% CO with oxygen in a closed tube. Moisture was kept constant by saturating the mixture at 0°C. Flame velocity was measured by a photographic method. At 400 mm. pressure, sharp maxima both at $2CO + O_2$ and at $4CO + O_2$ were found. Exploding at 200 mm. pressure, the stoichiometric maxima disappeared while that for the $4CO + O_2$ mixture remained. V. and S. conclude that the form of the curve for flame velocity in $CO + O_2$ mixtures is connected with a change in the temperature of spontaneous combustion for constant time lag and not with the hygroscopic condition as was suggested by Payman and Wheeler. Two curves. J.L.G.

**Increasing the output of Hoffman kilns.** N. A. Ponomarenko. *Stroitel. Materialy*, No. 11, pp. 3–6 (1936). P.B. & E.S.

**Industrial propane for flame cutting and general foundry use.** F. H. Andrews and E. A. Jamison. *Trans. Amer. Foundrymen's Assn.*, **7** [6] 324–36 (1936); see *Ceram. Abs.*, **15** [11] 343 (1936). H.E.S.

**Investigating fuel in plants.** K. Schultze and F. H. Zschacke. *Glashütte*, **67** [8] 125–29 (1937).—The determination of properties of coal, such as heating value, combustion, sulfur content, and reactivity, is discussed. Methods of procedure and apparatus used are briefly described. Illustrated. M.V.C.

**Manufacture of salt-glazed stoneware pipes and fittings.** A. Coulhon. Translated in *Brit. Clayworker*, **45** [539] 362–64 (1937).—C. describes a continuous kiln for pipe firing and discusses its efficiency. The kiln consists of two parallel galleries which are connected at their ends. Each gallery is divided into alternate firing and salting chambers and combustion chambers separated by pierced walls. *Ibid.*, **46** [540] 4–5 (1937).—C. discusses tunnel kilns for firing and salting pipes. Each kiln car is in the form of an actual single kiln. This practice is considered necessary to facilitate the removal of the saline vapor in the part of the tunnel kiln under the salting operation so that ware in the heating-up process will not be glazed. See *Ceram. Abs.*, **16** [6] 179 (1937). R.A.H.

**Maryland coals, their classification and analyses.** P. B. Place. *Combustion*, **8** [4] 37–39 (1936).—The individual seams of Maryland coals are traced through their various counties, the coals are identified by county and trade names, and their characteristics and analyses are given. Knowing the source of a Maryland coal and its moisture and ash content, a complete analysis may be set up from the values given in the tables which will be sufficiently accurate for most power-plant purposes. H.E.S.

**Propane and butane have specific value in production of luminous flames.** W. Z. Friend and E. Q. Beckwith. *Ind. Heating*, **4** [3] 187–91; [4] 285–87 (1937).—The advantages of propane and butane as fuel in industrial furnaces are mainly their high heating value of 2250 and 3200 B.t.u., respectively, their high C content and low dissociation point (about 940°F), and the luminous flame. The advantages of the latter are explained and compared with the flame of other fuel gases. Fifteen references. M.H.

**Secondary combustion.** W. Trinks. *Ind Heating*, **4** [4] 279–80 (1937).—Combustion in the combustion chamber of industrial furnaces is usually not complete; later, in some parts of the furnace where the combustion gases are more thoroughly mixed with the unburned gas and air, as in checkerwork or narrower passages, a secondary combustion sets in which might overheat or burn the material to be heated when it should be exposed only to a mild heat. Illustrated. M.H.

**Sulfur in coals.** B. Batta and E. Leclerc. *Ind. Chim. Belge*, **7** [12] 479–86 (1936); **8** [1] 3–7 (1937).—The behavior of sulfur existing in coals, especially as a nuisance, is described. R.W.D.

**Value of insulation in clayworking.** Anon. *Brit. Clayworker*, **45** [539] 365–67 (1937).—The theoretical side of heat transfer is discussed. Insulation with high-temperature conditions, the importance of insulating kilns, methods of insulation in high-temperature situations, and the insulation of kiln arches and walls as well as foundations are also discussed. R.A.H.

### BOOKS AND PREPRINTS

**Curves for the classification of coal.** J. F. Barkley and L. R. Burdick. *U. S. Bur. Mines Information Circ.*, No. 6933. 6 pp. Free. Results of the Sectional Committee on Classification of Coals of the A.S.T.M. are summarized, and curves which can be used for solving formulas quickly are included. R.A.H.

**Coal Deposits of Pike County, Ky.** C. B. Hunt, G. H. Briggs, Jr., A. C. Munyan, and G. R. Wesley. Supt. of Documents, Govt. Printing Office, Washington, D. C. 92 pp. Price $2.25. Most of the rocks in Pike County are nearly flat-lying strata of Pennsylvanian age. These rocks are grouped as the Pottsville formation, but the base of the Allegheny formation may be present on the high hilltops in the northwestern part of the county. The rocks consist of lenticular sandstone, shale, limestone, and coal beds, chiefly of continental origin. The county contains an estimated reserve of about 8 billion tons of coal in beds 12 in. or more thick that are minable by drift mines. In addi-

tion, several times that quantity is available to shaft mining in the lower Pennsylvanian rocks. R.A.H.

**Preliminary experiments for the development of a continuous electric ceramic kiln for high-temperature firing.** R. E. GOULD AND M. G. TOOLE. *Electrochem. Soc. Preprint*, 70—11, 16 pp. (1936).—Preliminary experiments, with the aim of developing a continuous electric ceramic kiln for high-temperature firing, bring out certain disadvantages of the electric kiln. These are higher initial investment, limited cross-section, necessity for heating element replacement, and comparatively high cost per unit of heat. Some of the advantages noted are ease in control of temperature and atmosphere, good heat distribution in kilns of small cross-section, a small temperature differential between the heating element and the ware, and easy recuperation of heat from the cooling ware. Additional advantages are a larger production for a given cross-section, elimination of saggers, and minimum repairs as a result of the absence of flame impingement.

**Progress report on tests of various electric heating elements for furnace temperatures between 1100 and 1500°C: I.** M. G. TOOLE AND R. E. GOULD. *Electrochem. Soc. Preprint*, 70—12, 21 pp. (1936).—The results of tests on silicon carbide resistors for electric heating for furnace temperatures between 1100° and 1500°C showed relatively high power loss, a material decrease in mechanical strength of bars with use, and failure when the resistance had increased 500%. No difference in resistance increase was noted for steady load as compared with on-and-off control. A more rapid resistance increase on bringing up to temperature after a shutdown and a daily increase when operated at maximum temperature were noted. A rapid current increase just prior to failure was also noted. An average life of 1700 hr. was observed. Tests on graphite resistors showed successful operation when protected from oxidation by propane gas, using a silicon carbide protection tube. The outside terminal block is the weakest point of the resistor assembly. A self-cooled terminal greatly improved the over-all thermal efficiency. Further tests are described using high-frequency induction heating. The general conclusion drawn is that nonmetallic heating units can be developed to operate at comparatively small cost per unit of material to be heated.

PATENTS

**Ovens or kilns for use in the manufacture of earthenware tile, brick, etc.** G. H. DOWNING AND H. R. HOLDING. Brit. 464,128, April 28, 1937 (July 23, 1936).

**Tunnel kilns particularly for pottery.** BERNARD JOSEPH MOORE. Fr. 794,149, Feb. 8, 1936; *Chem. Abs.*, **30**, 4641 (1936).

## Geology

**Barium.** CHARLES HARDY. *Mineral Ind.*, **44**, 54–57 (1935).—Germany and the U. S. are the chief producers and consumers of barium. Missouri produced nearly half of the U. S. supply. Other producing states were Calif., Ga., Nev., S. C., Tenn., and Va. Prices of crude ore were $4.00 to $7.00/ton. G.M.P.

**Bentonite, a new Italian mineral source.** FRANCESCO SAVELLI. *Miniera Ital.*, No. 2, pp. 49–52 (1936); abstracted in *Bibliografia Ital.*, **9** [7–9] 12 (1936).—A deposit of bentonite, $6SiO_2 + Al_2O_3 + 4H_2O$, was discovered by S. on the island of Ponza. Notes on the deposit are given. M.V.C.

**Beryllium deposits of Upper Egypt.** AUGUSTO STELLA. *Boll. Soc. Geol. Ital.*, **53** [2] 329–32 (1934); abstracted in *Bibliografia Ital.*, **9** [7–9] 12 (1936).—In the crystalline schists of the "mines of the emeralds of Cleopatra" of Upper Egypt there is quite a diffusion of emerald-colored beryllium in mica schists associated with other crystalline schists, under such conditions of deposition as to cause them to retain the "pneumoidatogenous" origin, and connected with the neighboring dioritic granite. M.V.C.

**Building nuclear crystal-structure models.** D. JEROME FISHER AND E. H. STEVENS. *Amer. Mineralogist*, **22** [4] 268–78 (1937).—A detailed description of a simplified method for building nuclear crystal-structure models of any complexity is given. Brief remarks on a muscovite model and color schemes are included. F.J.Z.

**Chemical study of some argillaceous shales of the marginal zone of the Flysch in the eastern Carpathians.** E. E. CASIMIR, M. DIMITRIU, AND V. PASCA. *Compt. Rend. Inst. Geol. Roumanie*, **20**, 181–91 (1932, published 1935); *Chem. Abs.*, **30**, 3751 (1936).—The schists which are rich in clay contain appreciable organic matter, but those rich in $CaCO_3$ do not. This fact indicates the important rôle of clay in transforming and fixing the organic matter. The content of the latter is 2.5 to 14%. It consists of 13% soluble bitumen with the remainder insoluble polybitumen. By heating slowly to 650° the organic substances in the shale decompose into approximately 15% gas, 27% oil, and 58% residue. In the case of the bitumen and distilled oil, per 100 parts of C there are 12.2 and 12.8 parts of H, respectively, but only 8.3 for the organic matter in the shale. There is a strong resemblance of the shale formation to that of the sapropelic deposits of saline lakes. This resemblance consists of the abundance of amorphous FeS which is in close relation to the bitumen content. Numerous chemical and mineralogical analyses are given.

**Clays of Mattagami.** ANON. *Clay Prod. News*, **10** [1] 15 (1937).—Drillings taken from six acres in this area in northern Ontario indicate that there is a considerable quantity of high-grade silica sand, kaolin, and fire clay. See "Refractory—," *Ceram. Abs.*, **15** [7] 218 (1936). M.C.S.

**Cobalt.** C. W. DRURY. *Mineral Ind.*, **44**, 105–10 (1935).—The consumption of cobalt has increased considerably. The production was principally from Belgian Congo, S. Rhodesia, and Canada. The U. S. imported 312 tons of ore from Canada in 1935. New York prices for the oxide were $1.39 to $1.49/lb. A short bibliography on cobalt is given. G.M.P.

**Colored earths and ochers for paints; an application of brick and tile clay.** A. C. *Rev. Matériaux Construction Trav. Publics*, No. 329, pp. 24–25B (1937).—The raw materials used to make brick and tile are also the source of the

colored earth pigments used in paints. Ochers are mixtures of clay and iron hydroxide or carbonate. They mix with water like a clay. The raw product is pulverized or diluted with water, sifted, and sometimes levigated. The color varies from yellow to brown or orange: with high iron oxide content, the calcined product approaches red and violet; less iron oxide and more lime gives orange; low iron oxide content with more clay and silica gives rose. Sienna is a brown variety of ocher with oxide of manganese; calcined, it becomes red-brown. Ochers containing organic matter which deepens the color can not be used except after calcination, which destroys the organic matter. Red ochers, of which hematite is the best type, must contain 70 to 75% iron oxide and 20% calcined clay after calcination; the color varies from red to violet. Green clay contains iron in the ferrous state. M.V.C.

**Comparison of methods for determination of clay content of soils.** R. Loebe, R. Köhler, and A. Abel. *Mitt. Lab. Preuss. Geol. Landesanstalt.*, No. 21, pp. 1–21 (1935); *Chem. Abs.*, **30**, 6104 (1936).—Seven samples of soil (3 clays, 1 loess, 2 marls, and a loam) were examined. Each was divided into seven portions by dispersion, and the amounts of "clay" were determined in each of these seven, and also in the whole undivided soil, by $H_2SO_4$ extraction (*TK*) and as the residue left after deduction of quartz, feldspar, etc. (*TR*). The total amount of clay deduced by adding that determined in each of the seven dispersed portions agrees fairly well with that determined for the original sample in four cases but shows considerable differences in three. The amounts determined by method *TR* are, on the average, 1.5 times that given by method *TK*. Dispersion tends to give too high an amount of "clay" in the final fractions, since these include a considerable amount of other residues. It is therefore not a reliable method, especially for binding soils.

**Cooling of the earth as a problem in metallurgy.** H. E. Stauss. *Sci. Monthly*, **42**, 371–74 (1936).—Since the science of metallurgy has given considerable study to the cooling and solidification of molten liquids, it is interesting to apply the results of metallurgy to the cooling of the earth. There are about ninety known terrestrial elements, most of them metals or metalloids. At first the temperature of the earth was probably high enough to maintain all the elements in one homogeneous liquid. While the earth was cooling and while it was still entirely liquid, chemical reactions began to occur which resulted in the formation of compounds, stable at high temperatures, either as solids or as liquids. Dissolved oxygen reacted to form many of the refractory oxides: aluminum oxide, silicon dioxide, and beryllium, magnesium, and ferric oxides. At the appropriate temperatures some compounds reacted to form additional compounds. The behavior of dissolved gases in the molten matter is discussed, and its resultant effect on volcanism and the earth's atmosphere is pointed out. H.E.S.

**Copper.** Percy E. Barbour. *Mineral Ind.*, **44**, 111–19 (1935).—Production and consumption increased during the year. The world production is controlled largely by eleven producers. An attempt was made to restrict production to improve prices. U. S. prices varied from 7.7¢ to 9.0¢ per lb. The total world production in 1935 was 1,454,000 tons. The U. S. produced 344,000 tons. U. S. consumption was 525,000 tons; the principal uses were for electrical manufacturing, autos, light and power lines, buildings, and miscellaneous purposes. G.M.P.

**Cryolite: index of refraction, birefringences, and crystal forms.** G. Cesaro and J. Mélon. *Bull. Sci. Acad. Roy. Belg.*, **22**, 362–72 (1936); *Chem. Abs.*, **30**, 5850 (1936).—From the experimental data obtained, values are given for $n$ as a function of the wave-length, for the three principal birefringences, and for crystallographic angles.

**Differential thermal analysis for determination of constituents of clays, laterites, and bauxites.** Jean Orcel. *Congr. Internat. Mines, Met. Geol. Appl., 7e Session, Paris, 1935, Geol.*, **1**, 359–73; *Chem. Abs.*, **30**, 8083 (1936); see *Ceram. Abs.*, **13** [6] 160 (1934).

**Distribution of clays and coal near Stourbridge.** F. T. Perrins. *Claycraft*, **10** [4] 176 (1937).—P. discusses the geologic history of the Stourbridge area, particularly the clay and coal deposits. M.C.S.

**Electrodialysis of soils: I, Electrodialysis by the rotating electrode.** A. N. Puri and R. C. Hoon. *Soil Sci.*, **43** [4] 305–309 (1937).—The rotating electrode shown diagrammatically is a modification of Puri's electrofiltration apparatus. It consists of a perforated copper cone resting on a glass funnel. An ordinary filter paper is used for holding the soil suspension. The rotating anode is cone-shaped and is made from a perforated sheet or gauze of gold or platinum. It is rotated at about 200 to 300 r.p.m. Currents as high as 0.5 amp. can be passed from a 220-v. circuit with a suitable sliding resistance. Electrodialysis, as revealed by the percentage recovery of exchangeable bases, is quicker with the rotating electrode than with the stationary one. Different exchangeable bases take varying lengths of time for displacement by the same current density. The order of their ease of displacement is Na > K > Ca > Mg. The volume of the electrodialysate is slightly greater and the maximum temperature of the anode chamber slightly higher in the case of the stationary electrode than in the case of the rotating electrode. G.R.S.

**Elimination of iron from clay and sand.** P. N. Grigoriev and V. T. Kashirina. *Sprechsaal*, **70** [1] 2 (1937).—Deferrization can be done with a sulfurous solution in either a hot or cold state. The sample of clay or sand is treated in water saturated with $SO_2$. Satisfactory results are obtained only with silicate minerals with not more than 2 to 3% impurities containing iron. Sulfurous acid easily dissolves the iron oxide which is usually present in clays and sands in this stage. M.V.C.

**Fluorspar.** Anon. *Mineral Ind.*, **44**, 177–82 (1935).—The production of fluorspar increased 44% and consumption 25% in 1935. The principal increases were in the steel and glass industries. Imports were about the same as 1934 and were 16,300 tons; 19% of the import was ceramic ground feldspar. The most came from Germany, Spain, and S. Africa; 102,000 tons were produced in the U. S. G.M.P.

**Genesis of tertiary silicate sandstone of the Donetz basin.** D. Bobrovnik. *Ukrain. Khem. Zhur.*, **11** [6] 469–82 (1936). P.B. & E.S.

**Gypsum.** Anon. *Mineral Ind.*, **44**, 313–15 (1935).—The gypsum industry is recovering from a heavy slump during depression years. Production increased 26% over

1934. Mine production was 1,937,000 tons. Very little is exported; 450,000 tons were imported, principally from Canada with some from Mexico and Italy. G.M.P.

**Illinois fluorspar as a chemical raw material.** FRANK H. REED AND G. C. FINGER. *Trans. Illinois State Acad. Sci.*, **28** [2] 129–30 (1935); *Chem. Abs.*, **30**, 3949 (1936).—A review of F minerals is given, covering their occurrence in Ill., their present commercial utilization, and possibilities for extension in use.

**Influence of humic colloids on certain physical and chemical properties of clay soils.** G. BARBIER. *Ann. Agron.*, [N.S.] **5**, 765–80 (1935); *Chem. Abs.*, **30**, 3563 (1936).—The extremely important rôle of humic colloids in the amelioration of clay soils is confirmed. The combination of clay and humic colloids exercises a much greater influence than either alone. The action of humic colloids in the increase in $H_2O$-holding capacity (owing to an increase in soil porosity) of clay soils is confirmed. Humic anions increase the resistance of suspended clay particles toward flocculating agents. When there has been a flocculation of the clay-humic mixture, the presence of humic anions fixed on the clay particles opposes dispersion. From the chemical point of view and in regard to the cations, the action of humic colloids is much less marked. To prevent loss of humic material, the application of soda and the alkalization of soil by overliming should be avoided.

**Investigations of Italian kaolins. The white clay of Schio.** E. CREPAZ. *Chimica & Industria*, **18** [4] 165–70 (1936).—The material is composed mainly of clay and kaolin ($Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$) and montmorillonite ($Al_2O_3 \cdot 4SiO_2 \cdot H_2O + nH_2O$), with 0.2 to 0.6% $TiO_2$, 1.0 to 1.8% CrO, 0.7 to 2.1% MgO, and 1.5 to 3.8% alkali. Physical and mechanical properties are described and curves are given. M.H.

**Kaolin deposits in Sardinia.** E. BORGHESAN. *Resoconti Assoc. Mineraria Sarda*, No. 4, pp. 126–27 (1936); abstracted in *Bibliografia Ital.*, **9** [10–12] 18 (1936).—Notes on the recently discovered deposits of Logudoro are given. M.V.C.

**Kaolin deposits of Serrenti-Furtei (Cagliari).** SILVIO VARDABASSO AND GIOVANNI GRIMALDI. *Resoconti Assoc. Mineraria Sarda*, No. 4, pp. 19–29 (1935); abstracted in *Bibliografia Ital.*, **9** [7–9] 12 (1936).—The complexity of the kaolinized clay sediments must be taken into account in their exploitation and evaluation. M.V.C.

**Kaolins and clays.** VEY. *Argile*, No. 168, pp. 7–11 (1937).—Clays, which are compounds of silica, alumina, and water in varying proportions, are divided into two groups: (1) clays containing 10 to 12% water, which have good resistance to acids and, when mixed with water, are easily molded and are used for pottery; and (2) clays with 22 to 25% water which are attacked by acids and are used as thinning agents. Geologically, clays lie at the lower part of formations and are considered as very fine-grained arenaceous rock resulting from the destruction of ancient rock which was transformed into mud and whose tiny particles remained long suspended in water. Analogously, kaolins are formed from the alumina-containing feldspars. The characteristics and compositions of French kaolins and clays are given. M.V.C.

**Large quartz veins of Great Bear Lake, Canada.** GEORGE M. FURNIVAL. *Econ. Geol.*, **30** [8] 843–59 (1935).—The large quartz veins at Great Bear Lake attain widths of 1000 ft. and have been traced along their strike for distances of 50 miles. F. presents the results of a mineralogical study of the wall-rock alteration along one of these veins. He concludes that the veins were formed by the deposition of quartz from hydrothermal solutions at "not very elevated temperatures" and that the great widths of the veins are due to the existence of wide zones of badly fractured rocks which were replaced in large part by the silica-bearing solutions. Several chemical analyses show the chemical changes which occurred during the alteration of the granodiorite. Illustrated by photographs, photomicrographs, and one curve. J.L.G.

**Lead.** ALLISON BUTTS. *Mineral Ind.*, **44**, 361–89 (1935).—Production of lead increased 12.2% in the U. S. which produces 23.9% of the world supply. The U. S. produced 336,700 tons of a world total of 1,420,300 tons. Australia and Mexico rank second and third. Missouri was the leading state in production followed by Idaho and Utah. Exports and imports were small in 1935. The New York price was about 4¢/lb. G.M.P.

**Method of measuring the capillary tension of soil moisture over a wide moisture range.** ROBERT GARDNER. *Soil Sci.*, **43** [4] 277–83 (1937).—The method consists of determining a capillary-tension curve for a grade of filter paper and then indirectly determining the tension curve for soils by placing them in contact with the paper at various moisture concentrations. Capillary-tension curves for soils may be determined by this method with sufficient precision to show the characteristic textural differences between soil types, and they may serve as a measure of moisture-storing capacity. G.R.S.

**Methods for working clay.** G. GERTH. *Ziegelwelt*, **68**, 28–30 (1937); abstracted in *Chem. Zentr.*, **1937, i**, 2845.—To obtain high-grade mixes, the flotation of clay is recommended and described. See "Preparation—," *Ceram. Abs.*, **15** [1] 48 (1936). M.V.C.

**Mineralogy's contribution to other sciences and to industry.** W. S. BAYLEY. *Amer. Mineralogist*, **22** [3] 147–68 (1937).—A review of the rôle of mineralogy in the ceramic laboratory and plant is included. F.J.Z.

**Mobility of exchangeable cations in the soil.** S. S. JARUSOV. *Soil Sci.*, **43** [4] 285–303 (1937).—The mobility of exchangeable cations depends upon the physicochemical properties of the adsorbents and their structural characteristics and determines the strength of the bond uniting the cations and participating in the exchange with the complex. This mobility also depends upon the degree of saturation of the complex by the cation. In soils completely saturated with one cation, the mobility of exchangeable cation varies twofold to threefold in dependence upon the properties of the soil. The highest mobility is shown by exchangeable cations in red soils, and the lowest, in chernozems. In the chernozem and podzolized zones, the mobility of the cations increases, as a rule. The unequal mobility of exchangeable cations in different soils seems to be due to differences in structure of the ion atmosphere of colloids in these soils. Only that part of the exchangeable cations (the proportions being different in different soils) which composes the looser, external part of the ionic atmosphere participates essentially in the exchange reac-

tions. In the case of two cations present in varying proportion in the complex of one soil and possessing different energies of absorption, the strength of the bond of one of them with the complex decreases with the increase of its saturation of the complex, and its mobility increases. The mobility of the cation of lower absorption energy changes relatively little with increase of the saturation of the complex by it. The mobility of exchangeable cations depends not only on the kind of soil and on the degree of saturation of the complex by them, but also on the kind of exchangeable cations accompanying them in the soil. The strength of the bond between the exchangeable cations and the complex in different soils, which determines the hydration of the absorbing complex, appears to be one of the factors on which the stability of soil colloids and the physical properties of soils in general depend. 24 references.

G.R.S.

**Nickel.** THOS. W. GIBSON. *Mineral Ind.*, **44**, 426–32 (1935).—Ontario, the principal source of nickel, produced 160 million lb. or 86% of the world supply. New Caledonia produces most of the remainder. There are no known important deposits in the U. S. G.M.P.

**Optical method for determining the content of alumina and silica gels in soils.** J. H. HELLMERS AND R. KÖHLER. *Mitt. Lab. Preuss. Geol. Landesanstalt*, No. 21, pp. 22–54 (1935); *Chem. Abs.*, **30**, 6108 (1936).—The indices of refraction of $Al_2O_3$ and $SiO_2$ gels of varying $H_2O$ content vary inversely with that content, accurately in the case of $Al_2O_3$, slightly less so in that of $SiO_2$. Thus $Al_2O_3$ + 84.40% $H_2O$ has $n$ = 1.50 to 1.53, and the same, air-dried (34.50% $H_2O$), 1.578 to 1.587; $SiO_2$ + 91.4% $H_2O$ has $n$ = 1.365 to 1.380, and air-dried (11.8% $H_2O$), 1.430 to 1.440. The indices of refraction of the air-dried gels correspond closely with those of hydrargyllite and opal, respectively. The variation produced by adsorption of the chief salts used for fertilization, etc., *i.e.*, KCl, $K_2SO_4$, $KNO_3$, $K_3PO_4$, and $K_2HPO_4$, was also examined. These are slight in all cases and in the direction to be expected, save in the case of phosphates, where it is much greater; this indicates chemical action. Similarly, the $n$ of Fe- or humus-stained particles varied with the amounts thereof present as indicated by the depth of color. The $n$ of artificial mixtures of $Al_2O_3$ and $SiO_2$ depends on the relative amounts thereof, the amounts of $H_2O$ present, and the amounts of alkali used in the preparation. There was no indication of chemical combination between $SiO_2$ and $Al_2O_3$. In regard to both $n$ and composition, such mixtures correspond with the clay minerals allophane, halloysite, and montmorillonite. The $n$ of artificial permutites depends on the $Al_2O_3$-$SiO_2$ ratio, the $H_2O$ content, and any absorbed salts. Permutite is to be regarded as a mixed gel. Zeolites show some resemblance both optically and chemically to permutites but clearly were formed under different conditions.

**Origin and composition of clays.** D. G. RUNNER. *Roads & Streets*, **79**, 53–56 (1936); *Chem. Abs.*, **30**, 1331 (1936).—R. discusses the origin, composition, and classification of the various types of clay common to the U. S. 24 references.

**Peculiar deposits of bauxite in Provence.** JACQUES DE LAPPARENT. *Compt. Rend. Soc. Geol. France*, **1934**, 64–66; *Chem. Abs.*, **30**, 1331 (1936).—The bauxite at le Montagne de Regaignas (Bouches-du-Rhône) occurs in three veins in Jurassic dolomite, 0.5 to 4 m. thick and 1.5 to 3.5 m. apart. East of Auriol on the Bouches-du-Rhône-Var border, it occurs in large pockets containing alternate layers of bauxite containing lignite, lignite fragments cemented by bauxite, and pisolitic bauxite. In both cases, it is thought that preëxisting bauxite has been washed into subsequently formed cavities in the dolomite.

**Petrography of some rocks from South Orkney Islands and the Antarctic archipelago.** DUNCAN STEWART, JR. *Amer. Mineralogist*, **22** [3] 178–94 (1937).—The results of a study of 114 thin sections of duplicate specimens collected by the Scottish National Antarctic (1902 to 1904) and the Swedish Antarctic (1901 to 1903) expeditions are given. It is suggested that the series of granite-diorite-gabbro eruptives of the northern region of the archipelago were the source of (at least) some of the sediments of the Jurassic strata of the area and, therefore, of greater age than that previously suggested (late Cretaceous or early Tertiary). F.J.Z.

**Process for the removal of iron oxide from silica sands.** F. W. ADAMS. *Jour. Soc. Glass Tech.*, **19**, 118–24 (1935).—Mention is made of the origin of sands and the impurities likely to affect their suitability for the manufacture of colorless glass with special reference to British sand deposits. Several chemical methods are referred to which have been tried in the past for treating sands to reduce their iron oxide content sufficiently to make possible their use for the manufacture of good quality colorless glass. A new process is outlined in which the sand to be treated is agitated for a short time at a temperature of 26° to 65°, with a solution of acid oxalate together with small quantities of ferrous sulfate.

**Rapid method for determining soil moisture.** E. M. EMMERT. *Soil Sci.*, **43** [1] 31–36 (1937).—The method is based on the fact that when water is added to concentrated $H_2SO_4$, a definite amount of heat is produced, proportional to the quantities of water and acid mixed. With a fixed quantity of acid, the rise in temperature will be definitely related to the quantity of water added and may serve as a measure of that quantity. The determinations may be made rapidly in the field with nothing but a thermometer, test tubes, a 2-cc. pipet, and concentrated sulfuric acid. Some provision must be made to weigh 1 g. of soil rapidly.

G.R.S.

**"Red earths" of Cirenaica.** ALVISE COMEL. *Boll. Soc. Geol. Ital.*, **54** [2] 313–16 (1935); abstracted in *Bibliografia Ital.*, **9** [10–12] 55 (1936).—The physicomechanical and chemical characteristics of three "red earths" of Cirenaica are given. M.V.C.

**Roweite, a new mineral from Franklin, New Jersey.** HARRY BERMAN AND F. A. GONYER. *Amer. Mineralogist*, **22** [4] 301–303 (1937).—The physical, chemical, and optical properties and X-ray crystallography are given for the mineral Roweite, $H_2MnCa(BO_3)_2$. F.J.Z.

**Significance of "filled" feldspar.** H. P. CORNELIUS. *Schweiz. Mineralog. Petrog. Mitt.*, **15**, 4–30 (1935); *Chem. Abs.*, **30**, 991 (1936).—Plagioclase crystals "filled" with clinozoisite and sericite or muscovite occur in certain granites, etc., of the Alps; occurrence of garnet, sillimanite, or quartz as "filling" material is doubtful. The plagioclase crystals, though retaining their form, are sometimes so much "filled" as to be indeterminable; in general, the

greater the proportion of anorthite, the greater is that of zoisite. The distribution of these "filled" plagioclases is stated, and theories of their origin are discussed. C.'s view is that it is a deep-seated phenomenon resulting from the action of $K_2O$ and $H_2O$ on plagioclase crystals under special conditions of temperature and pressure during mountain-building processes, so that optimal zones occur where these conditions were most favorable.

**Silex deposits of Davoli and Satriano in the province of Catanzaro.** GIUSEPPE RONZA. *Rend. Accad. Sci. Napoli*, No. 7–12, pp. 125–36 (1935); abstracted in *Bibliografia Ital.* (*Ind. e Mat. prime*), 9 [7–9] 14 (1936).—The structure and purity of the deposits make them of interest as raw material for the manufacture of crystal, ceramic, glass, and refractory ware. M.V.C.

**Sodium salts.** PAUL D. V. MANNING. *Mineral Ind.*, **44**, 541–48 (1935).—The sodium salts of importance are borax, carbonate, chloride, nitrate, and sulfate and are obtained from brines or saline deposits. The U. S. produces most of the world's supply of borax. Tetraborate and colemanite are produced principally in Calif. Exports of borax minerals increased 10% with no imports. The chief uses are for enameled iron, glass, soaps, flux, boric acid, and textiles. U. S. production of carbonate was 93,000 tons from natural deposits, chiefly in Calif.; 390,000 tons of sodium nitrate were imported; 75% of the world's supply is from synthetic sources. G.M.P.

**Soils derived from flint clays and from flint terrains of Picardy. Comparison with heavy soils.** G. JORET AND H. MALTERRE. *Ann. Agron.*, [N.S.] **5**, 16–43, 507–40 (1935); *Chem. Abs.*, **30**, 3559 (1936).—Comparisons are made by determinations of organic matter, N, soluble humus, lime requirement, reaction, calcification, and phosphoric acid (total and $H_2O$-soluble). Ratios between the first three of the above are also considered. Soils derived from flint clays are greatly decalcified; their $p_H$ is raised and many have a decided lime requirement. Diminished biological activities and the relative proportions of total organic matter, soluble humus, and N characterize these soils. They have a total $P_2O_5$ and $K_2O$ content comparable to heavy soils, but the analytical methods for determining the assimilable fractions in the flint-clay soils are imperfect. Water-soluble $P_2O_5$ and exchangeable $K_2O$ give more useful results. These soils are rich in fertilizing elements and have a higher proportion of the secondary elements (such as Mg, Mn, and Fe) than heavy soils. At equal reactions, alkaline or neutral flint-clay soils are a little more saturated in exchangeable bases than the heavy soils, and the relation exchangeable MgO/ exchangeable CaO is more favorable. An extensive bibliography is given.

**Studying clays and products with the microscope.** E. W. NIELSON. *Brick Clay Rec.*, **90** [3] 178 (1937).—The microscope performs an essential purpose in the control of raw materials and in the examination of finished products. Methods of using a petrographic microscope for determining the mineral constitution of raw materials and following the mineralogical changes caused by the heat treatment of the material are discussed. Grain size of the materials can also be checked microscopically. E.J.V.

**Substitution of German for foreign clays in papermaking.** VON POSSANNER, A. LAUBENHEIMER, R. WAGNER, AND R. JENKE. *Papier-Fabr.*, **34**, 459-77 (1936); *Brit. Chem. Abs.-B*, **56**, 126 (1937).—A large number of clays from different parts of Germany and some English clays were analyzed to compare their suitability for papermaking. Methods of analysis are described; these include fractionation by sedimentation in the presence of water-glass, screening through 170- and 270-mesh sieves and examination of the mineralogical composition of the residues, photocell whiteness determination, and retention in and effect on the properties of laboratory sheets of beaten, bleached sulfite pulp. The residues on the 270-mesh screen give a good indication of the final abrasive properties (Bekk method) of the sheets, whereas retention in the paper is governed mainly by the quantity of the clay fraction of $>5\,\mu$ particle size. Clays with very large fine fractions ($<2\,\mu$) will reduce retention. The finish of the sheets (Bekk method) is mainly governed by the quantities of particles $>20\,\mu$ present, increase in which tends to reduce the finish. The loss of finish due to these fractions, however, may be offset to a certain extent by the presence of large $2\,\mu$ fractions. Transparency of the sheets is practically unaffected by the different clay qualities, and whiteness is affected only to a small extent; 20% of ash in the sheets greatly reduces their folding-resistance; the effect, however, is least with clays having large medium fractions.

**Tin.** E. BALIOL SCOTT. *Mineral Ind.*, **44**, 566–85 (1935).—The International Tin Committee has regulated the supply of tin, resulting in a decrease of stocks and an increase in price. The average price in New York is about 50¢/lb. World production shows a general increase due to increases in quotas. A total of 146,000 tons was produced. G.M.P.

**Zinc.** S. D. STRAUSS. *Mineral Ind.*, **44**, 600–27 (1935).—The world's smelter output was 1,349,000 tons, a gain of 13%. Consumption in the U. S. increased 33% and production increased 17%. Little is imported or exported. The principal sources in the U. S. are the tri-state district of Mo., Kan., and Okla. and in N. J., Mont., Utah, Idaho, N. Y., N. Mex., and Nev. U. S. prices vary from 3.73¢ to 4.85¢/lb. G.M.P.

### SEPARATE PUBLICATIONS

**Barite deposits of Virginia.** RAYMOND S. EDMUNDSON. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 725, 17 pp. (1936); *Chem. Abs.*, **30**, 5909 (1936).—The Va. bedrock barite deposits in the Piedmont province are igneous. The mineral associations are indicative of high to intermediate temperatures. The hydrothermal minerals in the barite veins and replacement masses clearly indicate a magmatic source. Hydrothermal alteration (propylitization and silicification) of wall rock accompanies many of the veins. The Ba content of the enclosing rocks is exceptionally small and is inadequate as a source of Ba. Furthermore, adjacent rocks show no sign of leaching. Magmatic solutions are probably better transporting agents of Ba than meteoric solutions and the $SO_4^{=}$ is more readily obtained.

**Concentration of Georgia kyanite ore.** R. G. O'MEARA AND B. W. GANDRUD. *Amer. Inst. Mining Met. Engrs. Contrib.*, No. 98, 3 pp. (1936); *Chem. Abs.*, **30**, 3755 (1936); see *Ceram. Abs.*, **15** [4] 131 (1936).

**Geology, mining, and processing of diatomite at Lompoc, Santa Barbara County, Calif.** HENRY MULRYAN. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 687, 30 pp. (1936); *Chem. Abs.*, **30**, 2139 (1936).

**Résumé of work of the Nonmetals Division, calendar year 1936.** OLIVER C. RALSTON AND A. GEORGE STERN. *U. S. Bur. Mines Information Circ.*, No. 6934. 12 pp. Free. Technologic investigations of the Bureau on nonmetallic minerals are described under (1) occurrence, composition, and properties; (2) purification, preparation, and beneficiation; (3) processing and utilization; and (4) new facilities for new problems. R.A.H.

**Succession of minerals and temperatures of formation in ore deposits of magmatic affiliations.** WALDEMAR LINDGREN. *Amer. Inst. Mining Met. Engrs. Tech. Pub.*, No. 713, 23 pp. (1936); *Chem. Abs.*, **30**, 5908 (1936).—Most minerals in igneous rocks crystallize between 870° and 600°, the temperature generally decreasing with increasing $SiO_2$. Ore minerals separate out early, in part, but some of the metallic substances are held tenaciously and persist into the residual magma. The primary pegmatite minerals form at about 573°. Contact-metamorphic deposits crystallize generally below 573° and rarely as high as 1100°. Hydrothermal veins and replacement deposits form generally below 573° and some may form below 100°. After the main crystallization of the silicates, the residual magma, which is acid, consists mainly of $H_2O$ and volatiles, with much $SiO_2$ and various amounts of heavy metals. The acid extracts are neutralized or made alkaline by contact with surrounding rocks and ascend toward the surface, perhaps impelled by gas pressure from below, depositing minerals. When the solutions reach the zone of underground meteoric $H_2O$, further reaction occurs. Paragenesis of minerals (shown tabularly) usually is the same in hypothermal, mesothermal, and epithermal deposits. Colloidal solutions are most important in these dilute solutions and are produced generally by the reducing influence of $H_2S$, $Na_2S$, $Te_2S$, and $Se_2S$. Practically all sulfides including pyrite are precipitated first as gels. In colloidal solutions, the transportation of the sulfides is easy, and comparatively rapid deposition can be effected. After the normal sequence of sulfides and arsenides is formed, the Pb-Ag antimonides and arsenides, the argentite, the tellurides, the selenides, and the native metals are deposited. Parts of the Au and Ag solutions may be adsorbed by the sulfides and precipitated earlier with them. For $Ag_2S$ there is an important inversion point at 180°, above which it forms argentite, below acanthite. $Ag_2S$ was deposited from solutions stabilized by $Na_2S$ or $SiO_2$. Among the causes that might lead to the coagulation of the Au sol are escaping $H_2S$ and $CO_2$; the most important cause probably is the coagulation of the $SiO_2$ sol, which stabilizes the metal sol. The presence of $AuCl_2$ in hydrothermal solutions is highly improbable as is the long-continued existence of double salts of alkaline sulfide and AuS.

**Talc and soapstone in Washington.** HEWITT WILSON AND JOSEPH A. PASK. *Amer. Inst. Mining Met. Engrs. Contrib.*, No. 99, 25 pp. (1936); *Chem. Abs.*, **30**, 4235 (1936); see *Ceram. Abs.*, **15** [4] 132 (1936).

## Chemistry and Physics

**Centigram (semimicro-) analysis of inorganic substances: IV, Analysis of chemical glass.** W. JANCZAK. *Roczniki Chem.*, **16**, 377–83 (1936); *Brit. Chem. Abs.-B*, **56**, 240 (1937).—Identical results were obtained in analysis of glass for $SiO_2$, $Al_2O_3 + Fe_2O_3$, Zn, Ca, Mg, Na, K, and B by the decigram and centigram methods. The latter procedure involves an economy of 70% in time and of 90% in materials as compared with the former.

**Composition and constitution of the colloids of certain of the great groups of soils.** HORACE G. BYERS, LYLE T. ALEXANDER, AND R. S. HOLMES. *U. S. Dept. Agr. Tech. Bull.*, No. 484, 38 pp. (1935); *Chem. Abs.*, **30**, 4965 (1936). —The colloids of the chernozem group of soils are characterized by high ratios of $SiO_2$ to $Fe_2O_3 + Al_2O_3$ and $SiO_2$ to $Al_2O_3$ and by uniformity of colloidal composition through the profile. The prairie colloids have distinctly lower $SiO_2$ ratios than the chernozems but are essentially free from carbonates. The colloid profile is constant in composition. The gray-brown podzolic colloids are not sharply different in $SiO_2$ ratios from the prairie colloids but show more variation in profile. The lateritic and laterite groups have low $SiO_2$-$Al_2O_3$ ratios but very high $SiO_2$-base ratios. The podzol soils reflect in colloid composition the extensive fractionization which has taken place within the profiles. The analytical data have been correlated to develop a systematic relationship between the soil colloids independently of any assumption as to the causes of these relationships. Further evidence is obtained of the existence of five fundamental compounds resulting from the hydrolysis of minerals. These hypothetical acids are assumed to have the composition (1) $3H_2O \cdot Al_2O_3 \cdot 6SiO_2$; (2) $3H_2O \cdot Al_2O_3 \cdot 4SiO_2$; (3) $3H_2O \cdot Al_2O_3 \cdot 2SiO_2$; and (4) $3H_2O \cdot Al_2O_3 \cdot SiO_2$. The names suggested for these compounds are (1) montmorillonitic acid, (2) pyrophyllic acid, (3) halloysitic acid, and (4) allophanic acid.

**Constitution of the system $SiO_2$ + FeO + $Fe_2O_3$ + CaO (+ MgO).** T. NÉGRESCO AND W. J. COOK. *Bull. Acad. Sci. Roumaine*, **18**, 67–73 (1936); *Brit. Chem. Abs.-B*, **56**, 43 (1937).—Synthetic slags have been prepared by fusing $SiO_2$, $Fe_2O_3$, and CaO in air at 1650°, when MgO is taken up as an impurity (from the crucibles). Analysis reveals the presence of cristobalite, $Fe_2O_3$, FeO, magnetite, mono- and bi-ferrites of CaO and MgO, pyroxenes, wollastonite, diopside, $Fe^{II}$ akermanite, fayalite, and olivines of the series shannonite + forsterite. The slags may be classified into 12 groups and are represented on a quasi-quaternary diagram. It is inferred that $Fe_2O_3$ exists as such in the slags from steelworks and plays the part of an acid more feeble than $SiO_2$. CaO displaces FeO, and hence most of the slags contain free FeO; the progressive displacement is discussed for slags rich and poor in Fe.

**Correction in specific gravity and unit cell size of $Na_2O$-$B_2O_3$.** S. S. COLE, S. R. SCHOLES, AND C. R. AMBERG. *Jour. Amer. Ceram. Soc.*, **20** [6] 215 (1937).—An error in the original calculation of the unit cell size of $Na_2O \cdot B_2O_3$

and the specific gravity data (*ibid.*, **18** [2] 58–61 (1935)) is corrected.

**Crystal structure of sodium metaborate, $NaBO_2$.** Ssŭ-Mien Fang. *Jour. Amer. Ceram. Soc.*, **20** [6] 214 (1937).

**Determination of fluorine in sodium fluoride, fluorspar, electrolytes, and in slag from magnesium manufacturing.** K. M. Popov. *Kalii* [U.S.S.R.], **1935**, No. 10, pp. 24–27; *Chem. Abs.*, **30**, 2878 (1936).—By treating the sample with $SiO_2$ and $H_2SO_4$, all F is evolved as $H_2SiF_4$ which is determined by alkalimetric titration. The necessary precautions and modifications for various materials are described.

**Determination of sodium and potassium in insoluble silicates.** C. C. Miller and F. Traves. *Jour. Chem. Soc.*, 1390 (1936); *Trans. Ceram. Soc.*, **36** [2] 18A (1937).—Methods of determining soda and potash directly in the aqueous extracts obtained from silicates by the L. Smith procedure are examined; sodium is finally weighed as sodium zinc uranyl acetate and potassium as its perchlorate.

**Determination of sulfate ion. Microvolumetric-chromate method.** George G. Manov and Paul L. Kirk. *Ind. Eng. Chem., Anal. Ed.*, **9** [4] 198–200 (1937).—The microvolumetric-chromate method for sulfates has been investigated by a separate study of the effect of variables on each step of the procedure. The usual chromate methods contain several errors, notably the coprecipitation of chromate ion with barium sulfate and the oxygen error in the iodometric determination of dichromate. Procedures have been developed to minimize these errors and to eliminate them completely in some cases.

F.G.H.

**Determination of Young's modulus by flexural vibration.** G. Grime and J. E. Eaton. *Phil. Mag.*, **23** [152] 96–98 (1937).—The method of determining Young's modulus by observing frequency of flexural vibration of small samples of the material is discussed. This method is applicable to brick, tile, and materials of high internal friction, such as pitch and asphalt. See *Ceram. Abs.*, **15** [5] 150 (1936).

C.J.P.

**Effect of the sorbing properties of clays and of the composition of the sorbed complex on their ceramic properties.** A. V. Tereshchenko and B. E. Pindrik. *Ukrain. Khem. Zhur.*, **11** [5] 387–407 (1936).—Based on the newest conceptions of the nature of clays and of their interaction with aqueous solutions, changes of the most important properties of clays have been investigated as to their sorbing properties and the composition of the sorbed complex. The ceramically important properties of clays can be regulated by increasing their sorbing property and by changing the composition of the sorbed complex.

P.B. & E.S.

**Electrodialysis and cation exchange studies on soils of varying organic matter content.** A. L. Prince and S. J. Toth. *Soil Sci.*, **43** [3] 205–17 (1937).—The quantity of bases electrodialyzed is not a function of the $p_H$ of the field sample, but rather depends upon the total cation exchange capacity and the degree of base saturation. The addition of organic matter and phosphorus to the soil increases the acidoid-basoid ratio of the soil complex and consequently lowers the ultimate $p_H$ and increases the cation exchange capacity. Mobilization of iron and silica increases with decreasing ultimate $p_H$. Electrodialysis reduces the cation exchange capacity of all samples. The average silica-iron ratio in the dialyzate from the anode is higher than that from the cathode.

G.R.S.

**Incomplete atomic arrangement in crystals.** E. J. W. Verwey. *Jour. Chem. Phys.*, **3** [9] 592–93 (1935).—$\gamma$-$Fe_2O_3$, $\gamma$-$Al_2O_3$, and the oxide obtained by the electrolytical oxidation of $Al(\gamma'\text{-}Al_2O_3)$ are averaged structures with regard to the cations. Both the $\gamma$ and $\gamma'$ oxides have the same oxygen lattice but there is a distinct difference in the degree of incomplete arrangement of the cation. $\gamma'$-$Al_2O_3$ and $\gamma$-$Al_2O_3(Fe_2O_3)$ are intermediate cases between the amorphous state and the completely arranged state.

G.R.S.

**Modern metallography.** Anon. *Metal Ind.* [London], **49** [7] 156–57, 163 (1936).—An interesting adaptation of the beautiful crystal structures obtainable in metals and metal alloys is shown as a means of producing artistic and decorative effects on bowls, cups, boxes, etc., of metal.

H.E.S.

**Physical properties of disperse systems.** E. G. Richardson. *Science Progress*, **31** [123] 462–75 (1937).—R. discusses thixotropy of clay-water suspensions, the flow of solid suspensions in water, and similar subjects. Schmidt's equation for suspensions in turbulent motion is

$$\frac{\partial s}{\partial t} = \frac{\epsilon}{\rho}\frac{\partial^2 s}{\partial h^2}$$

where $s$ is the property transported, $\rho$, the density of the fluid, and $\epsilon$, the austasch or pickup coefficient. H.H.S.

**Plant methods of determining lime in slags, mixtures of raw materials, and cements.** N. I. Medved. *Tsement*, **3** [1] 23–27 (1935).—The determination in mixtures consisting of slag and limestone is effected by direct titration in the presence of methyl red as indicator. One determination takes 25 min. The calculation of the CaO content is effected by the titer of HCl standardized in respect to $Na_2B_4O_7 \cdot 10H_2O$ with methyl red as indicator.

P.B. & E.S.

**Rapid determination of aluminum and iron oxides in clays.** A. Lobanov and V. Zhitenov. *Zavodskaya Lab.*, **4** [10] 1277–79 (1935).—The method is based on the precipitation of sesquioxides by alkalis or ammonia. Their amount is calculated on the basis of the alkali or ammonia titrated. The analysis takes 4 to 5 hr. Only $SiO_2$, $Al_2O_3$, $Fe_2O_3$, $TiO_2$, and ignition losses are determined.

P.B. & E.S.

**Rapid method of determining silica with the aid of oxyquinoline in quartzites, silica and grog materials, and clays.** M. I. Volynetz and S. S. Bernsteyn. *Zavodskaya Lab.*, No. 5–9, pp. 107–72 (1936).—The method proposed avoids the use of a standard solution of oxyquinoline and thus simplifies the analysis. The dissolved silica reacts with molybdenic acid, forming silicomolybdenic acid; the latter gives, in some circumstances, a silicomolybdenic-oxyquinoline complex. The silica content is determined by dissolving the oxyquinolate in hydrochloric acid and by bromometrically titrating the oxyquinoline liberated. See *Ceram. Abs.*, **15** [10] 316 (1936). P.B. & E.S.

**Sensitive method for the determination of traces of elements of the rare earths.** M. Servigne. *Compt. Rend.*, **204** [11] 863–65 (1937).—By using electrical discharges

in a solution of rare earths, preferably in tungstate or molybdate of Ca, the spectra of rare earths, even if present only in traces, can be clearly distinguished; quantities as low as $10^{-7}$ g. could be detected. The method is described in detail and results for Sa, Dy, and Eu are given. M.H.

**Slag systems.** R. Hay, James White, and A. B. McIntosh. *Jour. West Scotland Iron & Steel Inst.*, **42** [Part 6], 99–104 (1935); *Chem. Abs.*, **30**, 1337 (1936).—The nonexistence of grunerite, $FeO \cdot SiO_2$, is established by thermal and optical evidence. A previously unidentified substance with $n$ 1.74 is a eutectic of fayalite and silica. In the ternary system FeO–MnO–$SiO_2$, a deep trough extends from 1155° (the melting point of the fayalite-$SiO_2$ eutectic), with a gradual rise in melting point, to 1200° at the rhodonite-tephroite eutectic. No ternary eutectic was found. The binary MnO–$Al_2O_3$ was studied thermally and optically. The addition of $Al_2O_3$ lowers the melting point of MnO from 1785° to the eutectic at 24% $Al_2O_3$ and 1520°. With further additions of $Al_2O_3$, the liquidus rises continuously to 2050°, the melting point of $Al_2O_3$. The compound $MnO \cdot Al_2O_3$, melting at 1560° incongruently, is hard and brittle, is amber but appears white under the microscope, is isotropic, and has an $n$ between 1.76 and 2.00. All melts in this system have low surface tension. $Al_2O_3$ is soluble in solid MnO. Thermal data and absence of eutectic at 50% $Al_2O_3$ indicate that MnO is soluble in the compound. The solution of MnO changes the color from amber to bright emerald green. The reaction of FeO–MnO–$SiO_2$ slags with C was studied at 1310°. The oxides were melted and then crushed and remelted with C rod, and the gas pressure was measured. The order of activity is FeO, knebelite, fayalite, and Mn silicate. Use of high-C steel as a source of C indicates the same order of activity. With excess MnO, Fe is a reducing agent. The resulting Mn alloys with the Fe and C. Work is in progress with white cast Fe as a source of C. FeO is the most active oxidizer in this ternary system. At 1310° fayalite is only partially dissociated. In the presence of MnO, stable Mn silicates are formed, lowering the concentration of free $SiO_2$ and thus increasing the free FeO. Mn silicates are less active toward C because they are less dissociated and because MnO is less reducible.

**Soil microbiology.** S. A. Waksman. *Ann. Rev. Biochem.*, **5**, 561–84 (1936); *Chem. Abs.*, **30**, 5703 (1936).—W. reviews the literature since 1932 and gives a bibliography.

**Systematic quantitative analysis of kaolin clays.** A. M. Zan'ko and G. A. Butenko. *Zavodskaya Lab.*, **4** [10] 1188–94 (1935).—The method eliminates the necessity of fusing with soda, the introduction of which usually is a source of error on account of the difficulty of washing out alkaline salts adsorbed by amorphous precipitates of silica and sesquioxides. Silica does not become practically insoluble, and therefore its recovery is more complete than in the usual method. One weighted sample is sufficient for direct determination of all elements, alkaline metals inclusive, that form the clayey matter; of special importance is the direct determination of aluminium. The determination of Al, Fe, Ti, and Mg in the form of crystalline "oxine" precipitates makes it easy to filtrate and wash them out quickly. A rapid volume determination of all elements except silica and alkaline metals is possible. See "Application—," *Ceram. Abs.*, **16** [1] 42 (1937). P.B. & E.S.

**Theoretical considerations of wetting.** L. Desalbres. *Bull. Inst. Pin*, **1936**, pp. 79–82; *Chem. Abs.*, **30**, 5854 (1936).—D. gives a mathematical discussion of the theory of wetting, bringing out the importance of both surface tension and interfacial tension.

**Validity of the formula of Mecklenburg. A new point of view of the dynamics of adsorption.** Dăn Rădulescu and Silviu Tilenschi. *Bul. Soc. Chim. România*, **17**, 313–21 (1935); *Chem. Abs.*, **30**, 6619 (1936).—The formula is not valid because it rests on the false hypothesis that the process of adsorption is exclusively a capillary condensation. It is shown that the formula is not verified experimentally. It is concluded that up to a certain concentration of the adsorbed substance in the adsorbent the adsorption must be complete, *i.e.*, the vapor pressure of the adsorbed substance must be practically zero. This complete adsorption must be independent of the concentration of the adsorbed substance in the gas stream. Experimental data are offered in verification of these conclusions.

**Viscosities of liquid-solid systems.** R. N. Traxler, H. E. Schweyer, and L. R. Moffatt. *Ind. Eng. Chem.*, **29** [5] 489–92 (1937).—A linear relation exists between the logarithm of the viscosity of viscous mixtures made from a particular liquid and a particular pulverulent solid and the volume percentage of the solid present. An index is given which evaluates the increase in viscosity caused by the addition of different mineral powders. This index measures the percentage increase in viscosity resulting from a 1% increase in the volume of the solid. The stability indices for a number of different powders are given. The viscosity of a viscous mixture of a particular powder dispersed in a given liquid is inversely proportional to the average thickness of the films of liquid separating the particles (as measured by the average void diameter). Illustrated. F.G.H.

**Viscosity formula for binary mixtures, the association degrees of constituents being taken into consideration: XII.** Tetsuya Ishikawa and Toshitomo Baba. *Bull. Chem. Soc. Japan*, **11**, 8–18 (1936); *Chem. Abs.*, **30**, 2818 (1936).—Applications of the Ishikawa equation to nonaqueous solutions of associated liquids are discussed.

**Viscosity phenomena of the system $KAlSi_3O_8$–$NaAlSi_3O_8$ and of perthite at high temperatures.** Koichi Kani. *Proc. Imp. Acad.* [Tokyo], **11**, 334–36 (1935); *Chem. Abs.*, **30**, 2068 (1936).—Six different chemical compounds belonging to the binary system $KAlSi_3O_8$–$NaAlSi_3O_8$ were investigated for the temperature range 1450° to 1300° by means of a rotating-cylinder viscometer and compared to natural perthite.

**Viscosity of slags.** L. V. Zverev. *Trudy Vsesoyuz. Nauch.-Issledovatel. Inst. Mineral. Syr'ya*, No. 79, pp. 3–38 (in English 39) (1935); *Chem. Abs.*, **30**, 2818 (1936).—Z. reviews the physicochemical principles involved in the problem of slag viscosity and the methods employed in its determination. Numerous tables, diagrams, curves, and 56 references are given.

BOOK AND PREPRINT

**Difficulties encountered in the determination of the decomposition potential of molten salts.** PAUL DROSSBACH. *Electrochem. Soc. Preprint*, 70—18, 4 pp. (1936).—An equation for expressing the polarization potential in the case of a reversible process is derived. It is pointed out that when anolyte and catalyte are not separated, the temperature coefficient of an observed polarization potential is not identical with that of an e.m.f. and conclusions based on the heat of reaction are not warranted. It is also pointed out that definite results can be obtained only when anolyte and catalyte are completely separated and when the current efficiency is 100%. Depolarization and polarization effects are discussed.

**Tables of Physical and Chemical Constants and Some Mathematical Functions.** G. W. C. KAYE AND T. H. LABY. Longmans, Green & Co., London, 1936. 8th ed. 162 pp. Price 14s. Reviewed in *Chem. & Ind.*, **55** [44] 861 (1936).—The tables have been brought up to date, the section on thermometry has been rewritten, and the sections on magnetism, X-ray spectra, etc., have been revised. The data given relate to general physics, astronomy, heat, sound, light, electricity, magnetism, rays, radioactivity, gaseous ionization, physical constants of chemical compounds, solubilities, minerals, gravimetric factors, the exponential $e^{-x}$, and mathematical tables intended to facilitate calculations arising out of the use of the book.

PATENTS

**Manufacture of boron carbides.** A. WACKER GES. FÜR ELEKTROCHEMISCHE INDUSTRIE, GES. Brit. 464,182, April 28, 1937 (Sept. 17, 1935).

**Manufacture of titanium dioxide and products containing titanium dioxide.** J. E. POLLAK (N. V Industrieele Mij. voorheen Noury & Van der Lande). Brit. 463,966, April 21, 1937 (Oct. 8, 1935).

**Process for making titanium dioxide.** H. W. RICHTER (American Zirconium Corp.). U. S. 2,078,279, April 27, 1937(April 13, 1934). In a process for the preparation of titanium dioxide, the step comprises hydrolyzing a titanium salt solution in the presence of a titanium oxide concentrate prepared by reacting a titanium-bearing material with a caustic alkali, treating the reaction product with water and /or weak acid to remove substantially all of the alkali, and drying the concentrate.

**Process of producing titanium dioxide.** H. L. RHODES (Glidden Co.). U. S. 2,078,278, April 27, 1937 (June 30, 1933). The process of producing pigment titanium dioxide from crude titanium dioxide comprises calcining the crude oxide with 0.1 to 2.5% of an alkali earth titanate, in the absence of other diluting pigments.

**Silicates of alkali metals and method of producing them.** J. D. CARTER (Philadelphia Quartz Co.). U. S. 2,078,836, April 27, 1937 (May 19, 1934). (2) The method of rendering more fluid an aqueous, soluble, alkali-metal silicate composition containing silica and alkali-metal oxide in a molecular ratio of more than 3.55 to 1 comprises adding to such solution a nonalkaline water-soluble organic peptizing material selected from the group consisting of sucrose, milk sugar, maple sugar, levulose, glucose, xylose, maltose, and galactose. (8) An alkali-metal silicate composition having a molecular ratio of silica to alkali-metal oxide of from approximately 3.55 to 1 to approximately 4.5 to 1 and containing in addition a member selected from the group consisting of sucrose, milk sugar, maple sugar, levulose, glucose, xylose, maltose, and galactose in amount sufficient to render the composition more fluid.

## General

**Apprenticeship.** F. R. HOADLEY. *Trans. Amer. Foundrymen's Assn.*, **7** [6] 289–97 (1936).—A recent survey of 170 foundries showed that less than 3% were training mechanics; 17% reported a shortage of skilled workers. In 1935, more than 46% of the employees were over 45 yr. of age. The failure to provide for future needs is quite evident. Basic necessities for any successful scheme are to hire boys properly qualified, to maintain their interest in the work, and to provide for practical and material instruction of the best type. H. discusses the details of the training plan of his company. H.E.S.

**Australian Clay Products Association annual meeting.** ANON. *Sydney Morning Herald*, March 17, 1937.—The annual report emphasized the endeavors made to popularize the use of stoneware pipe for house connections. H.H.S.

**Ceramic table tops.** STUART M. PHELPS AND EDWARD E. MARBAKER. *Ind. Eng. Chem.*, **29** [5] 541–47 (1937).—The commonly used materials are lacking in one or more properties that the ideal laboratory table top should possess. A recapitulation of the required properties is presented. A program of research resulting in the formulation and manufacture of a new ceramic material is described. In addition to the properties usually possessed by ceramic bodies, this material should have a low coefficient of expansion which imparts to it high resistance to thermal shock. The body is made impervious to liquids by impregnation with bituminous materials and subsequent special heat treatment by means of which the original pore spaces are filled with carbon in the form of coke. The properties of the new material are described and other applications are considered. Illustrated. F.G.H.

**Characteristics of ceramic bodies.** J. ANDRÉ LAVERGNE. *Rev. Matériaux Construction Trav. Publics*, No. 328, pp. 1–4B; No. 329, pp. 17–21B (1937).—Porosity values called the porosities (open, $P_o$; closed, $P_f$; total, $P_t$) are the constants characterizing the body to which they refer. They are the relation of the volume, $v_o$ (open), $v_f$ (closed), $v_t$ (total), of the pores to the volume, $V$, of the body. The absorptive power is a constant defined by the relation of the total weight, $P_e$, of the water absorbed to the dry weight, $P_s$, of the body. It corresponds to the open porosity. The penetration and absorption are variables, functions of the quantity of liquid which penetrated the body at the moment considered. Impregnation is the relation of the quantity, $v$, of liquid which the body contains at the moment considered to the total quantity, $v_e$, of the liquid which the body is capable of absorbing.

The values actually given as expressing the porosity (open) of bodies to which they refer seldom represent this porosity (open). Most frequently they are the penetration values. The method established by L. seems to permit, in every case, the direct determination of this open porosity simply and rapidly. The variable values, $D_v$ (true density), which recognize $D_r$ (real density) as a limit can present, in certain cases such as in research, etc., a marked interest owing to their possibility of being determined with great precision. The values, $D_r$, only rarely agree with the values, $D_m$ (density of material or specific gravity), unless they are determined by the vacuum method, by the method by expansion exactly applied, or by L.'s method (superheating); in these three cases it is a question of a body containing no closed pores. The values, $D_r$, can not be designated by the names "real density" or "true density"; the values heretofore published as $D_r$ values in reviews are almost always $D_v$ values. The relation porosity closed $= 100\,\frac{Dm - Dr}{Dm}$, would not generally give the value of the closed porosity, $P_f$, because (1) the value, $D_r$, which figures in this relation is almost always a value, $D_v$, and (2) this relation really is applied to all ceramic bodies only in the general form, $P_f = 100\,\frac{Da\,(Dm - Dr)}{Dm \cdot Dr}$.

M.V.C.

**Employee security.** LEWIS K. URQUHART. *Factory Management & Maintenance*, **95** [2] S-358-68 (1937).—U. considers various plans for workmen's compensation, old-age pensions, unemployment compensation, salary savings, credit unions, employee housing, dismissal compensation, group insurance, and profit sharing. J.L.G.

**Fighting silicosis in industries.** BERTHEAU. *Sprechsaal*, **70** [5] 59–61; [6] 73–75 (1937).—B. reviews various measures taken to prevent the formation of dust during working. Illustrated. M.V.C.

**Influence of atmospheric humidity on the degree of dispersion of dust as recorded by the Owens meter.** E. D. PICK AND L. G. CHOURCHILOV. *Higiena Truda Tekh. Bezopasnosti*, **13** [4] 22–29 (1935); *Chimie & Industrie*, **36**, 62; *Chem. Abs.*, **30**, 6609 (1936).—A study of the factors governing the characteristics of the Owens dust meter, whereby it has a tendency selectively to register fine particles, proved conclusively that there exists a definite relationship between the humidity of the air passing through the instrument and the fineness of the precipitated particle. When air is drawn through, the diameter of the large particle does not exceed 3.6 $\mu$ and the average diameter is 0.55 $\mu$; these diameters increase with rise in humidity, reaching 7.4 and 1.3 $\mu$, respectively, at 96% humidity. It can be supposed that the selectivity of the Owens meter is due to a selective distribution of condensed moisture on the smaller particles of dust, which is favored by the impact velocity of the air against the glass and by the smallness of the condensation chamber. It is thus closely dependent on the principle of operation of the instrument.

**Is cast iron a brittle material?** G. MEYERSBERG. *Giesserei*, **24** [2] 28–31(1937).—The terms "brittle" and "tough" are defined as referring to the deformation taking place in a material just before fracture; brittleness means that this deformation is little; toughness, that it is large. No definite limit can be drawn between brittleness and toughness. There is a gradual transition from the one to the other condition; not the material by itself, but other conditions, such as kind, duration, magnitude, and type of stress and shape, temperature, and treatment, determine the classification of a material as tough or brittle. Brittle materials, according to this definition, are glass and porcelain, while cast Fe has only one property in common with these materials, *viz.*, the brittle behavior under static stress. Cast Fe shows, however, under heavy stresses, a certain plastic deformation which does not occur in brittle materials, and it therefore can not be classed among these. Eleven references. M.H.

**Mineralogical study of silicosis.** R. C. EMMONS AND E. H. STEVENS. *Amer. Mineralogist*, **22** [4] 256–67 (1937).—Silicosis is caused by the presence of colloidal silica in the tissues of the lung. Such silica apparently destroys living tissues by collecting on cell walls. Its source is believed to be inhaled particles of quartz and silicates which remain in the lung long enough for the mildly alkaline lung fluids to attack them chemically. The removal of such dust particles from the lung is facilitated by the presence of other dust particles which serve as flocculating agents. It is recommended that, if such protector dusts are not present in an environment where the silicosis hazard prevails, they be added as an economical and effective means of protection. The suggestion is also made, based on experimental data, that other minerals not yet recognized may create similar health hazards. A microscopic examination by a competent petrographer should be made to determine what protector dusts are needed in a given case. F.J.Z.

**Modern practice of boiler feed-water treatment.** J. BIGEON. *Ind. Chim.*, **23** [265] 87–92 (1936); [267] 259–64; [269] 406–10 (1936).—B. reviews the well-established classical process of water-softening and the usual methods of control under the following headings: (1) troubles in feeding boilers with natural water; (2) water-softening by distillation, by base exchange, and by chemical processes; and (3) comparative costs of water-softening, (*a*) lime-soda process, (*b*) the same process followed by a treatment with trisodium phosphate. He gives an account of newer methods of treating boiler feedwaters which are designed to prevent scale formation. The chemical properties of lime-soda water softening are discussed. The beneficial action of trisodium phosphate as a softening agent is explained. B. also deals with the prevention of scale formation and the removal of scale. R.W.D.

**Pathogenesis of silicotic tissue changes: I, Experimental production of silicotic welts by quartz and colloidal silicic acid.** H. SIEGMUND. *Arch. Gewerbepath & Gewerbehyg.*, **6**, 1–17 (1935).—S.'s objective in Part I of this pathological series is the action of pure crystalline quartz on body tissue. Rabbits were intravenously injected with the minerals selected. Not only pulmonary effects were studied but also those of circulatory media (veins and capillaries in connection with reticulo-endothelia) in the distribution of mineral-dust particles to the liver, spleen, and bone marrow. The kind of dust injected is emphasized, together with its collective effect when brought to

the organs mentioned, especially the liver with its clear transparent structure and advantageous mesenchymal parts over those of the lungs or spleen for this particular inquiry. S.'s results confirmed those previously attained by Gardner in America and Giese in Germany. S. details his procedure; results after 6 months of quartz treatment show indurations of tissue and actual quartz depositions in organs, without coöperation from any other injurious factor. No mechanical action of the quartz dust influenced the indurations. The quartz went into solution and this soluble colloidal silicic acid was actually observed as making the connective tissue changes. The finer the quartz particles, the more quickly appeared the indurations. Finest particles appeared in the periportal tissue of liver and lymph nodes. Other liver changes occurred, with corresponding ones in spleen and bone marrow. This study demonstrated that soluble silicic acid has fibroblastic potency. K.R.

**Perspective and discovery.** JAMES G. VAIL. *Bull. Amer. Ceram. Soc.*, **16** [5] 185–88 (1937).

**Social security records.** LEWIS K. URQUHART. *Factory Management & Maintenance*, **95** [3] S-370–80 (1937).—U. discusses the records which employers should keep for social security reports and recommends desirable forms for large and small plants. Illustrated with facsimiles of actual forms and photographs. 22 figures. J.L.G.

**Testing dust filters.** OSKAR NEUMANN. *Gasmaske*, **8**, 65–70 (1936); *Chem. Abs.*, **30**, 6609 (1936).—Various means of testing dust filters are described and illustrated by diagrams and photographs.

**Visual promotion of ceramics.** H. E. SIMPSON. *Bull. Amer. Ceram. Soc.*, **16** [5] 211–13 (1937).

PREPRINTS

**Economics of power.** L. W. W. MORROW. *Electrochem. Soc. Preprint*, 70—14, 6 pp. (1936).—A comparison is made of fuel-burning and hydro-power plants as to location, capacity, and costs. Considering that (1) power costs are about the same in all parts of the country, (2) power is not the dominant factor in locating an industrial plant, and (3) power is cheapest and best when the plant is located near the point where it is used, it appears unlikely that industry will move to the sites of new hydro-power plants. With the cost of transmitting electricity about 2.5 times that of transportation of coal by rail for distances from 50 to 100 miles, with sufficient coal to last 5000 years, and with the construction of superposed high-pressure installations for stations already located at the loads, the trend in power-cost reduction is in the direction of less expensive and better operating fuel-burning plants, not toward Diesels and hydro plants.

**Power developments and electrometallurgical industries in the Pacific Northwest.** C. F. FLOE. *Electrochem. Soc. Preprint*, 70—13, 5 pp. (1936).—Upon the completion of the extensive hydroelectric developments in the State of Washington, there will be available over 3 million horse power. A large percentage of this power will be offered to electrometallurgical industries, largest single consumers of electric power in the world. The important natural mineral resources of the Pacific Northwest are briefly reviewed, and the possibilities are considered for the large-scale production of aluminum, magnesium, ferro alloys, calcium carbide, and other electrochemical products at the new dam sites.

**What the electric furnace has done for civilization.** P. H. BRACE. *Electrochem. Soc. Preprint*, 70—10, 8 pp. (1936).—The early beginnings of the electric furnace are briefly described. B. sets forth the effects of metallurgical electric furnace technique upon ways of living in modern times with specific reference to the part played by the electric furnace in the production and uses of aluminum, magnesium, beryllium, chromium, tungsten, calcium carbide, phosphoric acid, silicon, manganese, and tantalum. Its use as a processing tool in the shaping of metals and in "copper brazing," etc., is mentioned.

PATENTS

**Glazing ceramic objects.** SCHÜTTE A.-G. FÜR TONINDUSTRIE. Fr. 790,776, Nov. 27, 1935; *Chem. Abs.*, 30, 3194 (1936).—A plastic clay is suspended in water and diluted, preferably with ice, to a specific gravity of 1.2 or less, and small amounts of known liquefying agents (alkali, etc.) are added. The deposit is separated and ceramic objects are coated with the liquid and fired. The suspension may be concentrated by evaporation.

**Method of utilizing slag.** E. R. POWELL (Johns-Manville Corp.). U. S. 2,078,158, April 20, 1937 (June 21, 1933). In making an article from material of the type of blast-furnace slag, the method comprises providing a supply of the material in molten condition, admixing intimately therewith an agent adapted to develop gas in substantial amount at a very high temperature that is above the temperature of the molten material, raising the temperature of the resulting mixture to the very high temperature, thus causing the agent to develop the gas and produce voids in the mixture, and then solidifying the void-containing product.

**Porous body.** HANS BUCHLOH (Pen-Chlor, Inc.). U. S. 2,077,512, April 20, 1937 (July 7, 1934). In the process for the manufacture of porous bodies suitable for filtration, the steps comprise mixing an inorganic solid inert granular material of the group consisting of pumice stone sand, granulated ceramic matter, and quartz sand with a mixture of the still liquid to plastic condensation product of a phenol and formaldehyde in the so-called A-state of condensation with a hardening agent of the group consisting of oxalic acid, a reactive metal oxide, benzene sulfochloride, and *p*-toluene sulfochloride, the ingredients of the latter mixture being present in such proportions that it is self-hardening at atmospheric temperatures, and, without heating within a period of about 24 hr., shaping the resulting mass and allowing it to harden.

*A Heap of Living*
*Makes the Home*

*A Heap of Study*
*and*
*Unremitting Work*
*Brings Success*

*A Faint*
*Heart Never*
*Achieves*

*Only He*
*Who Determines*
*To Do*
*Succeeds*

*Why*
*Platitudes*
*of These Sorts?*

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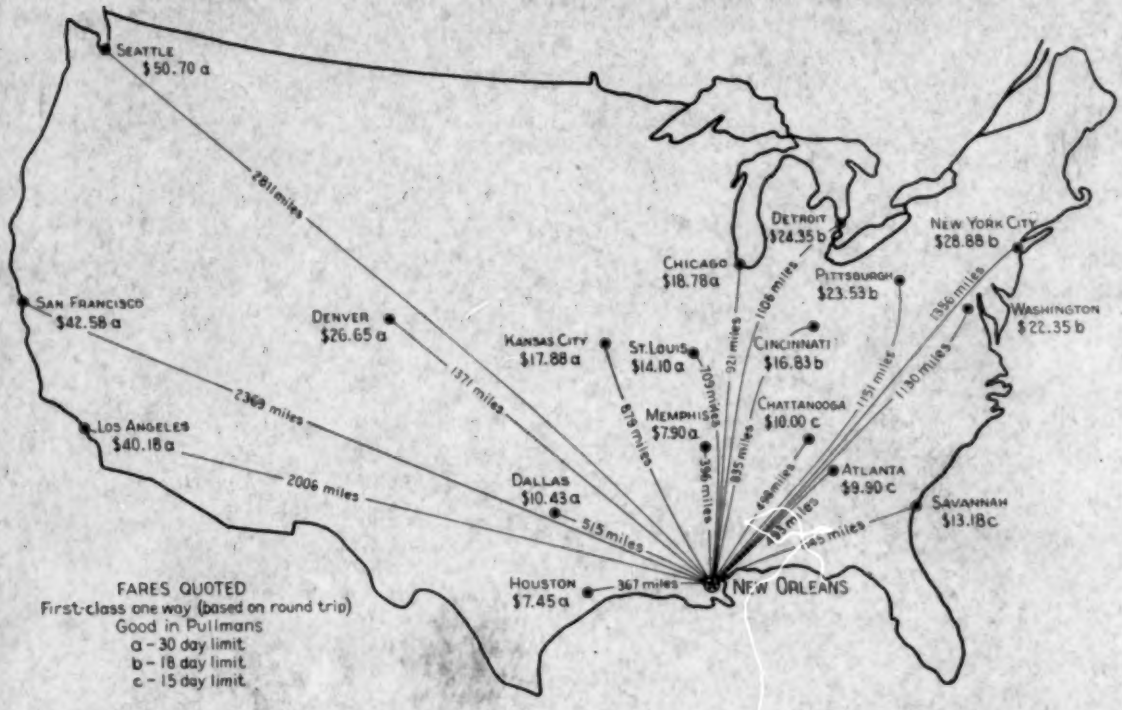
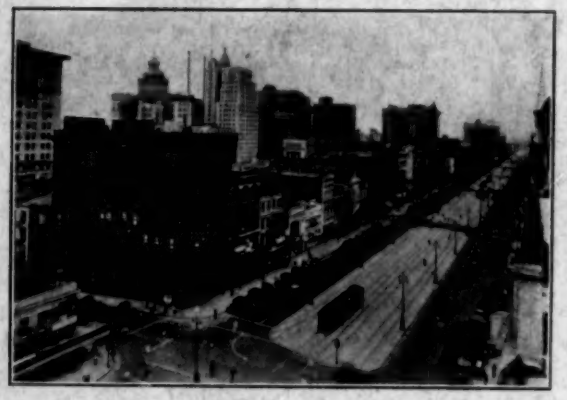
16—7, Ceramic Abstracts, pp. 193-239

# Fortieth Annual Meeting
# AMERICAN CERAMIC SOCIETY
# March 27-April 2, 1938
# New Orleans, Louisiana



Canal Street: With modern New Orleans on the left and ancient New Orleans on the right.

One of the world's famed thoroughfares. Rebuilt in 1928 in terrazzo marble at a cost of $3,500,000; extending from Eads Plaza on the Mississippi River, five and one-half miles to the Lake Front Park on Lake Pontchartrain; 171 feet wide.

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1. **Planned Program:** One can not obtain alone the planned combination of advantages.
2. **Expense:** Both travel and hotel will not be more than usual for most members.
3. **Time:** Only one extra day for those from the greatest distances.
4. **Personal Advantages:** Historical places unusual; extensive engineering constructions; people of achieving determination and enlarging conceptions.
5. **Vacation:** A happy and profitable combination vactionally and vocationally.